TROPICAL FRUITS.

By Mel T. Cook.

Chief of the Division of Vegetable Pathology of the Cuban Agricultural Station.

II.—Pine-Apple.

Who has not admired the beautiful fruits of the pine apple as we see it in our local markets and who has not tried to picture the growing plant? Did it grow upon tree, shrub, or herb? Did it have beautiful, sweet scented flowers which were as attractive as our northern apple blossoms? All these and many more questions have come to us from our students and in many cases have been unanswered.

Next to the banana and the orange the pine-apple is the best known of the tropical fruits found on our northern markets and most of us are less acquainted with its characteristics and the methods of cultivation than we are with those of the banana, which was described in the June number of this Journal. In fact, the peculiar and varied characteristics and habits of many of the members of the pine-apple family are of as great interest to the professional botanist as to the layman.

The pine-apple is supposed to be indigenous to tropical America, but is now cultivated in nearly all tropical and sub-tropical countries in which the conditions of soil and moisture are suitable. The plant consists of a rosette mass of long, narrow, more or less upright leaves with sharp points and edges. In fact it presents a striking resemblance to the Yuccas which we grow so abundantly for ornamental purposes. except that the leaves are fewer in number, slightly longer, broader and thicker. In most varieties the edges are serrated, which makes cultivation difficult. From the center of this mass of rosette leaves extends a shoot from two to four feet in height, tipped by the fruit. A shoot bears but one fruit and new shoots are produced each year. In well cultivated

fields, many of these shoots must be removed in order that the others may produce good fruits. The flower is aborted, is six-cleft, with six stamens and a single style. The fruit is composed of the entire infloresence, the ovaries and the bracts becoming fleshy and consolidated into the mass with which we are familiar.

Unfortunately the people of the north rarely have an opportunity to enjoy a first class pine-apple. In order to ship to any great distance it is necessary to cut the fruit rather green and also to use especially solid varieties. As the northern fruit grower uses his best fruits at home and ships his Ben Davis apples, so the tropical fruit grower, uses his white or sugar loaf pine apples and ships his red Spanish variety.

In Cuba the plants are grown in ridges, but in Florida the flat cultivation is used. The relative merits of these two methods depends largely upon the character of the soil and the amount of moisture. Slat and cloth sheds are also used in Florida as a protection against frost and sun.

Since the flowers are aborted the plants do not produce seeds although minute ovules are formed in the early development of the ovary. The plants are propagated by means of the "coronas," small plants produced just beneath the fruit, and from "criollas" (creolyas), which are suckers or shoots produced from the body of the plant. The "criollas" bear fruit about six months earlier than the "coronas," but the "coronas" are said to produce much stronger and much more durable plants.

The first crop will be harvested in from twelve to eighteen months, depending upon the character of the plants and four or five good crops will be produced of which the third will usually be the best. The cultivation of the pine apple was introduced into the United States about 1850, and has been fairly successful in Florida. However, it is always subject to more or less uncertainty because of the frosts. With the development of new varieties, improved cultivation and improved shipping facilities the pine apple is destined to become a far more important food product in the future than at the present time.

The pine apple belongs to the family *Bromeliaceae* and is known in botanical literature as *Ananassa sativa*, Schult. The majority of the members of the family are tropical and many of them are strictly epiphytic in nature. So different in appearance

are the members of this family that no one except an experienced botanist would ever suppose them to be related. Who would ever suppose that the so-called southern moss (*Tillandsia usneoides*, Linn), which grows so abundantly upon the trees of our southern states is classed in the same family as the pine-apple, and yet such is the case. In the West Indies the epiphytic bromeliads growing upon the trees are very abundant and give a characteristic appearance to the landscape. Many of these species look like small pine-apple plants and rest erect upon the branches of the tree, frequently in great numbers.

Another very characteristic bromeliad of the West Indies is *Bromelia pinguin*, Linn., or the so-called "rat pine." The plants are three or four feet high and bear a striking resemblance to the cultivated pine-apples. The leaves are rather broad-toothed and spiny, bright green, but becoming pink and red with age. The flowers are collected into a very dense panicle, are reddish and pubescent. The fruits are separated and are as large or larger than an ordinary plum and have a very acid taste. These plants are used abundantly for hedges, for which they are very serviceable.

Aside from the pine-apple for food, the "rat pine" for hedge, and a number of others for ornamental purposes, the family *Bromeliaceae* is at present of but very little economic importance.

PLANT ECOLOGY IN THE HIGH SCHOOL.
By WILL SCOTT,
High School, Terre Haute, Ind.

This paper is limited to that phase of plant ecology which deals with plant societies. A brief survey of the development of the subject will assist in getting a clearer view of this phase as it is applicable to high school work.

It has long been observed that plants grow in well defined societies. It has been noted, for example, that cactuses and yuccas grow in one group, deciduous forest trees, spring annuals and certain ferns in another; while such plants as water lilies Nymphaea, Nuphar) rushes and Sagittaria former a third group. During the latter part of the last century investigations were begun to determine if possible the causes of these formations.

There have been four epoch making contributions, besides a large number of other valuable papers. The first of these was made by Warming, in 1896. He invented the term "plant societies" and said that they were determined by the water content of the soil. He divided all plant societies into three main classes: the xerophytes, mesophytes and hydrophytes. The salt marshes, according to another basis of classification, were called halophytes.

In 1898 Schimper pointed out the important distinction between edaphic and climatic factors. He showed that latitude, elevation, winds, etc., determined great regional groups, such as arctic tundras, prairies, deserts and forests; while the local variation in plant grouping was due to local or edaphic factors, such as soil, light and slope.

In that year and the year following Graebner published the results of a laborious piece of work. He found that there was a definite relation existing between the physical and chemical properties of the soil and the species which grow upon it.

The fourth and probably the most important of the four contributions was that of Cowles, published in the February and March numbers of the *Botanical Gazette* for 1901, under the title of "Physiographic Ecology of Chicago and Vicinity." In testing the already offered theories he found that they were true, but not sufficient to explain all the facts as he found them in the field.

He found that a peat bog was very different from a river swamp; that the plant societies of a young limestone valley and a young sandstone valley were more alike than those of a young limestone valley and an old one. Such observations as these led him to accept the factors of Graebner and Warming, but also to pronounce them insufficient. After extensive studies in Tennessee, Atlantic coast, Michigan, and his own vicinity, he reached the following conclusions: (1) That plant societies cannot be explained when viewed as static things; (2) that only when viewed as to their origin and life history do they become significant; (3) that, given a temperate and equable climate, their origin and life history are closely related to the physiographic development of a region.

In explanation of this last point it may be mentioned that in a young topography such as the recently glaciated part of northern Indiana, there are xerophytic hills and hydrophytic swamps

and lakes, with a relatively narrow mesophytic region intervening. As the processes of weathering, erosion and sedimentation act on these hills and swamps the topography is brought nearer and nearer to planation and with this change the mesophytic zone becomes broader and broader, while the xerophytic and hydrophytic areas become more constricted. The climax type of a topography is planation, and that of plant formations is the mesophytic society. It may be noticed that as the topography advances from one form to another the plants are displaced by species better fitted to live in the new conditions. In any given location one group is imposed upon another, so that a vertical section showing the plants found in the different stages in its development would give a fairly good key to its physiographic history. These changes are not made suddenly, but are so gradual that in any plant society there are usually remnants of a former condition and forerunners of plants that are to displace existing ones. These societies often lag behind their cumulative causes; for example, when a lake is formed quite a period elapses before a typical lake flora exists. Plants march forward not in confusion, but in well defined zones. These zones have dominating plant which give them color. The middle of a zone is static or nearly so. The border line between two zones, the zone of tension as it is called, is very significant. Here the struggle between species is very sharp. The conditions here are not what they once were. The species which once maintained their supremacy are being crowded out by those which have been living in a similar condition just outside the zone of tension.

With this brief survey of the factors governing the origin and development of plant societies the questions to be considered are: How much of it is good for the high school? Under what conditions can that part be incorporated in the course with profit? How may the subject be presented?

In the high school only the factors worked out by Warming and Cowles in the water content of the soil and the physiographic factor should be considered. The regional distribution is usually included in courses on physical geography. The factor which Graebner proposed presupposes too much knowledge for consideration in a high school course.

Under what conditions is the course feasible: (1) The course

should be preceded by at least one-half year of general botany and enough physical geography to give a clear notion of the physiographic processes. If a knowledge of these laws has not been worked out previously their study will have to be incorporated in the course on ecology. (2) A region must be available where plants grow under natural conditions, as anything artificial disturbs the orderly sequence of societies. (3) A fair degree of skill in the identification of species is necessary. (4) Conditions must be such that the major portion of the time alloted to the subject may be spent in the field. Where the teacher cannot supervise the field work in person it is possible that the work will be done thoroughly only by those who have become intensely interested in their previous study of botany. This argues that it should be made an elective.

How should the course be presented? (1) The class should be divided into sections containing from two to four students. Each group should be assigned a problem and held responsible for it.

In the selection of areas for study the teacher should exercise the greatest care. Level areas over which one set of conditions maintain should be avoided as they are valuable only in a comparative study.

A section along a meandering stream, a bit of lake margin with its adjacent slope, a swamp or pond would furnish an ideal problem, for here the physiographic processes are changing the topography with such rapidity that the movement is easily discerned.

I suggest that the following points be worked out and in the order given: (1) A careful map should be made of the area under consideration. (2) The plants should be listed and their location and relative numbers indicated on the plot. Then the zones, with their characteristic plants, should be worked out, and also the general areas, i. e., the xerophytic, mesophytic and hydrophytic areas. (3) Then the physiographic processes should be considered. Regarding planation as the climax, is the movement progressive or regressive, or, if both are present, in what part of the area is each found? (4) Then to these processes should be related the plant zones. From that time, these zones will not be viewed as static things by the student, but as groups

of species in progressive movement, their line of march being determined and accompanied by the changes in the topography of the region. Finally all irregularities should be worked out and accounted for.

The teacher's aim should be to leave the student with a clear insight into the dynamics of plant distribution.

HIGH SCHOOL GEOGRAPHY

By Fred J. Breeze,
High School, Delphi, Indiana.

The lack of definite understanding as to just what geography is, the failure of schools to provide the necessary field and laboratory work, the absence of special geographic training on the part of the teacher, and the notion that any one can teach geography, all lead to the unsatisfactory condition of this science in our high schools. This paper deals briefly with some of these defects, and then presents a few suggestions concerning a one-year course in high school geography.

Successful geography teaching demands that the teacher possess a definite idea of the nature and aim of this subject, yet there is too often the lack of this thorough understanding. Consulting various sources one finds a bewildering difference of opinion as to just what geography is. Yet among eminent geographers of Europe and America there is a fair agreement on this matter. Davis of Harvard, and Dryer of our own state, have been of most service in giving us a definite conception of geography.

Geography deals with man and his physical environment, but the interrelations between man and his environment are not the whole of the subject. The mutual relations among the various elements of this environment are an essential part of it. The relations between man and earth cannot be intelligently understood until the relations existing among the elements of environment are grasped. These elements can be grouped under relief, climate, and plant and animal life; and the mutual relations between relief and climate, and between relief and climate on one hand and plant and animal life on the other hand constitute the first half of geography, which is physical geography or physiography. The second half includes the mutual relations between man and his material

environment. Man responds to the influence of environment either in yielding to it or in modifying or subduing it. This human response to nature is the second half of geography and includes parts of our so-called commercial and political geography. Davis has named this half of geography "ontography," a term which we will doubtless find quite useful. Geography in high school has been weak in that the human element has been neglected, and to-day there is a growing demand for a greater emphasis upon the ontographic half of the subject. Commercial geography has come into our schools in answer to this demand. But it is a mistake to think that commercial geography is all that there is to the second half of this science. The earth is impressing itself upon the whole institutional life of man and this institutional life is ever modifying the earth. But it is the industrial and political life that are most influenced by environment and which are most active in changing environment. Just how natural features affect or often direct historic movement is well shown in Brigham's recent book entitled "Geographic Influences in American History." We need better texts in commercial geography, but we need more a book that will embody the industrial and political phases. But more than all we need a book that instead of dividing geography into physiography and ontography and treating each separately will take up these phases and treat them side by side. Though no text book has done this, yet we can do some of this kind of work in our study of local geography.

We are pretty well agreed that out-door work in geography is just as necessary as laboratory work in physics and chemistry; yet field trips, I imagine, are quite infrequent affairs. Several things conspire against field work. The public too often looks upon the excursion as a mere picnic and can not see any good in it; discipline is hard to maintain and it is difficult to center the pupil's attention upon the desired things; the suitable locality for the work is not easily accessible, and school programs are not elastic enough to make excursions possible; but above all these, is the teacher's unfamiliarity with field work. College trained men and women are very often not at all at home among out-door things. The teacher who has never taken more than half a dozen field trips in his life is unable to be of much service, and so these field trips yield little of geographic value. But all these difficulties

must be overcome, for keen geographic insight can come only by observation and study of real geographic items. A stream gives far more information concerning stream action than any book can, and hills and valleys are the only good sources of knowledge of hills and valleys. It is possible for nearly every school to have access to a small area that may serve as a geographic unit, and excursions can be made to it in order to study its physiographic and ontographic elements.

Part of our trouble in geography comes from the fact that the teacher is not an actual geographer, that he has not developed the geographic vision, has perhaps never seen a natural feature with the eye of a geographer. The locality around the school is the geographic laboratory, and the teacher must be familiar with it. He must take long walks through fields and forests, over streams, valleys and hills, for only in this way can he secure a very necessary part of his equipment. That teachers are not better trained is due very largely to the failure of many of our universities, colleges, and normal schools to give this science the place it deserves. A few schools like the Indiana State Normal and Cornell University have recognized the importance of the subject and have put the work in charge of scholarly geographers. Another favorable sign is the fact that each year there is an increasing number of colleges offering summer courses in geography with provision for the much needed field·work.

In closing I wish to present a few suggestions concerning the year's work in high school geography. First I would like to see the terms "physical geography" and "commercial geography" dropped and the plain word "geography" substituted. The present text books have made this separation, but the teacher can develop the physiographic and ontographic phases side by side especially in the study of local geography. In using the commercial geography text the work can be strengthened by a fuller treatment of certain important geographic principles. All the texts are too full of statistics which are of little use, while general principles are too briefly treated. Again the course in geography should be elastic enough to permit the study of certain important subjects or certain phases of subjects which may be just outside the border of geography. For example, if a high school is situated in a rich geological field and geology is not in the course it is

well to depart from the main subject long enough to give the student a little accurate knowledge of the geology of his own home region. It is often worth while to turn aside from the regular subject to take up some closely related subject; but it is very essential that we know just when we turn aside and how far we turn aside. Every high school is situated in a locality rich in geographic problems connected with the early, pioneer life; and I want to urge that some of these problems be taken up. The pupils under the guidance of the teacher will do this work with great interest and profit. Since the coming of the white man great changes have taken place in our natural features and in our industrial and social life which have great geographic significance. The early history and geography of the country are so closely linked that there is a common field for the historian and geographer. Here is an illustration of the many problems that may be profitably studied. In an old map of Carroll County there are marked over fifty flour and saw mills in operation. To account for the passing away of these mills is a problem that will require considerable investigation and some good, hard thinking before it is solved. Railroads brought in the steam engine and fuel so that a steam mill could be put in a more advantageous location than old water mills. Forest removal has put an end to lumber manufacture and in part has produced the great reduction in the flow of our streams. A few years ago a mill, of not less than ten or twelve horse-power was operated by a stream that is now a very small rill; a high school pupil measured the fall at the old mill site and the volume of water and found the stream able to produce but two horse-power. Many other points enter this single problem which the pupil readily pursues. Such work, I believe to be real geography, has high educational value, and is of service to the community at large.

A SCHOOL COLLECTION OF ROCKS, MINERALS AND SOILS.

By George W. Low.

Punchard School, Andover, Mass.

Many schools have for use in connection with Physiography, and other sciences, more or less extensive collections of rocks and minerals. The following is a plan of arranging and cataloguing such a collection, so that it may be of the greatest possible use and the material most available for class work.

Paper labels pasted on the specimens are undoubtedly a nui-

Fig 1.

sance; they are apt to become detached and lost and, when in place, often cover up important sections of the specimen. The first step in the permanent arrangement of the collection is to put on each specimen, with a small brush, a small oval or rectangular block of black enamel paint. This block of paint is not large and should be at some place where it will cover nothing of importance. When the black enamel is dry, make with very small brush and "flake (lead) white" a number in small figures on the black background. This number is the only label necessary on the specimen itself, and cannot become detached or easily defaced.

Fig. 2.

'A shallow card-board tray is provided for each specimen. This is for convenience in handling and will, besides, save desks and tables much of the scratching which results from use of rock specimens. These card-board trays, similar to card-board box covers, but stronger, may be purchased, in great variety of sizes, of a box manufacturer.

PUNCHARD SCHOOL
ANDOVER, MASS.
DEPARTMENT OF SCIENCE

NO. *595*   DATE *May 23, 1905*
LOCALITY. *Andover, Mass.*
From ledge in rear of school building
REMARKS: *Gneiss.*
Note large plates of mica.
This is a metamorphic rock.
COLLECTOR, *G. W. Low*

Fig. 3.

The specimens are arranged by numbers in the exhibition case. In each tray is a label, like Fig. 3, with the number of the

specimen, the locality, finder, and name of the rock or mineral. These labels are not gummed. If the class exercise is to identify minerals, these slips may be taken out and the pupil be given simply the numbered specimen.

A card catalogue of the specimens is a convenience. For this, cards like the one shown in Fig. 4 may be used, bearing information similar to that on the tray slip and, in addition, book references concerning the material.

PUNCHARD SCHOOL.   SCIENCE COLLECTION.

No. *595* Date *May 23, 1905* Collector *G. W. Low.*
Locality *Andover, Mass. Near school building.*
Remarks *Gneiss.   Note large plates of mica. Other minerals?*
Much of the country-rock of this town is metamorphic rock, similar to this.

References *Dana : pp. 464-470.*
Tarr : pp. 407, 413, 34.
Crosby : pp. 55, 68, 108.

Fig. 4.

A collection of soils is of much interest and of considerable value as part of the general scientific collection. For this collection small bottles with large mouths (vaseline bottles) should be provided. Each specimen of soil or disintegrated rock is put in a separate bottle. The number is painted on the bottle as on the specimens, and the sample is catalogued as the others. A very much larger collection of soils may be made than would at first be thought. In observations extending over a month a small class in Physiography brought in more than twenty-five characteristic local soils, all surface soils. Sub-soils might well be collected also. The soils collected will be found useful in connection with the study of mechanical and chemical work of erosion and other topics in Physical Geography.

A scientific collection arranged as outlined above will be found to be in the most useful condition possible. If the collection is a large one some such arrangement is necessary if anyone is to know what is on hand and where it is. It is worth much to have a collection of such a nature and so arranged that the pupils can take pride in it.

Such a collection will grow rapidly through the pupils' interested efforts.

THE EDUCATIONAL VALUE OF THE HISTORY OF CHEMISTRY.

By H. N. Goddard,
State Normal School, Oshkosh, Wis.

One of the most notable of all assemblages in the world of arts and science occurred in St. Louis during the last week of September, 1904, in connection with the Louisiana Purchase Exposition. Here were gathered the great scholars and scientists of the universities and institutions of learning of the world. Here was provided opportunity for exchange of ideas among the greatest living minds. What more imposing sight could have been offered to the apostle of knowledge than the opportunity to look into the faces, study the personality, and listen to the words of the greatest scientists and scholars of his generation? It could scarcely have been more remarkable had all the princes and rulers of the world, all the heroes of modern battle, and all the living statesmen of the nations been gathered together in the common cause of civilization and humanity, and one had an opportunity to study the political progress of his generation in the very faces of its heroes.

How the heart of every student of chemistry must have thrilled at the presence of such men as Arrhenius and Van't Hoff and Ostwald and Ramsay and Rutherford and others, who have unlocked so many of chemistry's secrets during recent years! And this says nothing of many other brilliant lights who were present, representing other branches of arts and science. All honor to these great men of science of today. It was certainly a great privilege to see them and an inspiration to hear them, and feel the presence of their personalities. One could well have

afforded to spend money and time to attend the notable gathering
at St. Louis in order to take advantage of this privilege and
receive such inspiration.

. But a greater company of the great men of science is open to
our acquaintance among the leaders and investigators of the past,
and there is no field of science in which this is true in a more
remarkable degree than in the subject of chemistry.

The names of Boyle, Priestley, Lavoisier, Dalton, Avogadro,
Dumas, Davy, and a host of others cannot fail to excite the won-
der and admiration of all who have followed the achievements
of science and can be moved by the attainments of the human
mind.

These men, although materially dead, yet live, like all the
heroes of history, in their heroic achievements. These live in the
triumphs of their investigations into the mysteries of science and
in the heritage they have left us from the secrets of truth.

A study of the problems which these men met, of the disad-
vantages and difficulties which they overcome, and of the won-
derful accomplishments which crowned their efforts, cannot fail
to be of the highest educational value. Every student of chem-
istry should appreciate the heritage of science today and should
understand what a tremendous advantage we reap through the
achievements of these men.

In the first place, it is valuable for one to try to place himself
in the position of these earlier students and try to look at their
problems as they saw them. We are often inclined to wonder
how great minds could have fallen into so many errors and mis-
conceptions about questions which now seem very simple and
almost matters of course, even to comparatvely untrained minds.
But the average young student fails to consider how these things
came to be matters of course, and how they would look if our
knowledge along all lines was limited to that of a century or more
ago. Students need to understand how very small was the body
of data which was available to the early investigators. It may
all seem easy to us after certain truths have become a very part
of the intellectual fabric of a generation; but to them these truths
were not only unknown, but in very many cases were absolutely
opposed to the current thought of the time. There is the great
lesson here of the power of conventionalized thought and tradi-

tion on the minds of men, and one is confronted with the thought freighted with tremendous significance, that we, too, are in great danger of being blinded to the truth by the erroneous beliefs and traditions of our own generation. This is a lesson which these earlier minds have for every student who would know the truth.

Again every student of science should learn something of the great difficulties which have been overcome in the progress of this line of study. He can only thus appreciate the magnificent triumphs of the human mind and the splendid work which has been accomplished for the world, often under the greatest difficulties. The story should be known of how Scheele subjected himself to deprivation and even poverty in order that he might give his time and talent to scientific discovery. And it might be asked, what did he accomplish? He discovered oxygen, which somebody else discovered about the same time, and which every one knows of now, and a yellow, disagreeable gas which sets people coughing in its presence. Was his time wasted, or his sacrifice in vain? Every student should know that the stimulus which this humble student gave to scientific research by his discoveries can hardly be overestimated.

The story of Roger Bacon should be told,—of his splendid talent, of his untiring efforts to illuminate the darkness and ignorance of his time by the searchlight of truth, and of the persecutions which he endured as a result.

The lessons of self-sacrifice and of loyalty to truth which are shown by these and many others are of great educational value. The opportunity for such lessons can scarcely be excelled in any other line of study outside of the field of science. And such lessons are especially needed in these days of commercialism and self-aggrandizement, when it is so common to associate successful careers only with the accumulation of wealth.

There is valuable training in studying not only the truth in the earlier theories, but in discovering the defects and errors, and in endeavoring to see how these were gradually sifted out and how truth finally triumphed. Here the lesson should be taught that even these erroneous ideas contributed helpfully toward the general advance of truth by stimulating study and research along certain lines in the effort to disprove false theories, thus hastening the final establishment of truth.

Here is opportunity, too, to arouse the respect and honor which are always due to sincerity and earnestness of purpose; even the erroneous opinions may have been held and defended. Only respect and admiration can be aroused by a study of the lives and work of Stahl and Priestley and Scheele and many of the alchemists, who defended theories which were afterward shown to be wrong. Such training cannot fail to be of great educational value in developing the right attitude of mind toward the men and problems of today, problems which were never more freighted with importance, nor ever demanded broader or more fair-minded treatment.

At the same time it is possible that such training will do much in arousing the best ambition and talent among our students in the direction of investigation along some of the lines of research which offer such rich possibilities at the dawn of the new century. Some one has said that the best thing that a teacher can do for a student is to arouse in him an appetite for knowledge. An acquaintance with the great champions of knowledge in the field of science and the wonderful work which they did is a most potent influence in stimulating such an appetite.

In his "Ascent of Man" Drummond develops an inspiring climax when he skillfully draws the picture in the minds of his readers of the great scientists, all zealously at work, each in his own particular field, the biologist with his microscope, the chemist and physicist in their laboratories, the astronomer with his telescope, the geologist with his hammer, each looking earnestly for some great principle with which to solve the mystery of the universe, but too busy to take any notice of what was being done by his associates. Suddenly one looks up and with a cry of "Eureka!" hastens to announce his discovery, when lo! each of the others has found the same great principle in his field of thought. The great centralizing and unifying truth of evolution has been revealed. However figurative this picture may be it illustrates vividly how this principle permeates all lines of thought and study today. We are quite too likely to look for its exemplification and application in the biological studies only. This principle finds wonderful and peculiar exemplification in the development of chemistry.

The subject has been surrounded by many conditions which

have caused it to develop slowly. The unit of its activity is marvelously small and its reactions are hidden mysteriously away from our direct observation even by the most powerful microscope. Furthermore, the superstition and selfishness and ignorance of the ages have combined to stifle its growth. It has been under the edict of the church and the ban of the state, because of its subtle and mysterious activity. It has been opposed by the greed and the avarice of the centuries.

Its marvelous triumphs over these foes furnish a lesson in the development of truth which can scarcely be equaled in any other line of thought. Our students should be impressed with these lessons and inspired by their significance as a prophecy of the future triumphs of all right and truth.

Here is an opportunity too often neglected by the chemistry teacher. In our effort to acquaint our students with the vast field of information on the subject, and show them all the interesting and practical applications of the science, this rich field of the past is nearly or quite crowded out. Is it not true, as some one has said, that "Chemistry of today is overburdened with facts?" The vast field of chemical knowledge may well be traversed by the technical chemist, or specialist each in his own line; the investigator may wisely explore new fields for truth, but comparatively little of either is open to the student in the secondary school. What we as teachers in such schools can do is to acquaint our students with the fundamental principles of the subject, let them see a few of the interesting applications of these, and then not neglect to inspire them with the splendid story of the growth and development of the science, how it has moved forward little by little, now retarded by error, but again pushing forward with tremendous bounds under the guidance of truth, until with the dawn of the present century its achievements are the wonder of the world.

Let us see to it that our students learn the names and know of the work of the great minds which have contributed toward this result. Let them know of the progress of chemistry as an aid to medicine under Paracelsus, of the discoveries of Scheele and Priestley, of the indefatigable labor of Laviosier and his keen insight in sifting out the truth, of the untiring labor and perseverance of Dalton in his working out of the laws of definite and,

multiple proportion, of the broad scholarship and talent of Boyle, freely devoted to the problems of his time. History as commonly taught says but little of the achievements of these and a host of others of equal lustre, and yet their lives and work have a significance educationally scarcely excelled by any of the accomplishments of statesmen or the deeds of battle.

Ever student of chemistry should receive this rich heritage. Through the inspiration of these examples he should be helped to become an earnest and sincere seeker after truth in whatever sphere his life may be directed. Through some knowledge of the triumphs of the human mind over superstition and error he should come to have a large appreciation of the wonderful intellectual inheritance which is freely bestowed upon the present generation.

Through a tracing of the gradual development of science through all its devious ways to its present position, he should come to understand the great evolutionary forces which are ever working, not only toward higher types of organic life, but also toward a fuller understanding of truth and a more perfect expression of it.

Most of the facts of chemistry will be quickly forgotten by the majority of students. Many of the principles of the subject will find little application after the work has been completed; but the lessons of its development, the inspiration of its triumphs, and the influence of its spirit may permanently affect the attitude of mind and remain as abiding possessions.

ON THE RELATION OF RESEARCH TO THE TEACHING OF CHEMISTRY.*

By CHAS. BASKERVILLE.

The College of the City of New York.

Without entering into any unnecessarily enlarged discussion in this presence, I rather think that my hearers will agree with me when I say the ultimate object of education is moral autonomy. By that I would mean freedom from domination of blind authority. Man must be taught to think for himself and to think

*Address before the Chemistry Teachers' Club of Greater New York, at Hotel Savoy, December 17th, 1904.

aright. As Hegel has said, "Human history is·a progress in the consciousness of freedom."

We are perfectly aware that science largely depends, when the instruction is given in accord with modern approved views, upon such methods. This is particularly true of the laboratory instruction in chemistry.

Unfortunately, we Americans in our haste to acquire so-called knowledge, stuff our mental stomachs with hunks of facts, with consequent intellectual indigestion. From what I have been able to learn of the methods of the teachers of chemistry in Greater New York, this is not true. Very correctly the method is largely inductive in spite of the menacing examinations of the regents.

The student with sufficient instruction to intelligently follow a plan, the outline of which he receives, is required to work out his own salvation in the laboratory. In short, the pupils are veritable Crusoes, placed on islands of facts and phenomena with limited resources in the way of material and tools and required to construct raiment, and protection from the elements, provide sustenance to avoid mental hunger and for the continuance of cultural existence.

One beholds a picture of life in the words of Stanley Hall when he said:

"For years I have collected pictures of children of all sorts, and my collection now numbers many hundreds. The very finest expression on the face of a child or infant seems to me to be that of open-eyed and often open-mouthed curiosity and wonder. The objects of nature charm and entrance the soul, which for the moment becomes almost one with her. This state is akin to that striven for by all the ecstasy-cults from Plato down to Dante in his first vision of the Rose of the Dawn. It is Schopenhauer's 'adequate artistic contemplation,' in which for a moment even the pain of existence is forgotten, and man becomes all eye and all ear envisaging the embodiments of the purest ideas. It is the 'hedonic narcosis' of the best modern aesthetic theories. This divinest thing in childhood, which only bad school methods can kill, which prompts the primeval experiments of infants in learning to use their senses, limbs and minds upon nature, is the root of the spirit of research, which explores, pries, inquires, so per-

sistently, and often so destructively in older children, and comes to full maturity in the investigator behind the telescope or microscope, in the laboratory, seminary, library, or on exploring expeditions."

It is not so long ago that school men learned that it is proper to send the whole boy to school, and science came into the curriculum. We need not defend the device which causes and encourages the student to learn how to discover. It defends itself. Each one of us has done his little research in college or university, and knows that it was but an extension of his experience as a boy.

"The weakest thesis, which generally makes a tiny contribution to the sum of knowledge, puts the author—as every man of material culture must be once in his life—beyond authority, books, custom, tradition, or habit, where he can take a fresh, independent look at reality. He ceases to be a passive receptacle; he escapes the insidious surfeit of knowing merely and doing nothing, and produces something. He acts from scientific insight, critical test, and personal conviction."

Having once breathed that fragrance of the new, having once been allowed to pluck a seed from the unknown storeroom of the Almighty, having once nursed it into a flower, however beautiful or unattractive, I fail to see how one, by the very fever of the thing, could look on that one creation and not be swept along by the desire to make a garden of such joys, for each birth is a happiness, not solely for selfish pleasure, but that the world might also look in and rejoice.

Are we consistent, therefore, gentlemen, when we require our students of all ages and grades to investigate, for they work out what is unknown to them, and not search out the new ourselves? I look upon it as a duty we owe to the dignity of our profession, that we see that such may not be laid at our door.

German students aspiring to academic honors must do original work. The professional chairs are always filled by those men. This is becoming more and more the case in America. I know of two departments of chemistry in good places where they want teachers of chemistry now. The authorities would like to have men who have had some experience in high schools, but they insist that they shall be investigators.

Into our schools over the country have gone many men, who

by influence have been foisted upon the teaching profession, and others who frankly stated their desire for temporary associations in pedagogy. Their number happily is growing less, and I have taken it that none such was a member of this club. The appeal therefore is not for self, but lends itself for the betterment and uplift of the whole profession.

What would we now materially be enjoying if the framers of our declaration of independence had merely come together and talked over such matters? There were doubtless declarations framed independently by every member of that great body in advance. I know of two others.

Practical application of the verb "to do" brings results. If we are serious, we must frankly face certain propositions with good temper. To that end we may ask ourselves one or two questions.

Are the chemistry teachers of Greater New York members of the American Chemical Society? On comparing the register of that Society and this club, it will be noted that one-half are members of both. One-third of that half are college or university teachers. Draper has well said that the first line of defense of a country is the educational institutions, and the second the scientific societies.

Do they attend the meetings of the Chemists' Club? Much of the formidable strength of the Naples biological station is in the social conferences of the table occupants.

Do they subscribe to the journals, as SCHOOL SCIENCE AND MATHEMATICS, and read them?

Chemistry teachers are frequently unwilling to begin research unless upon some great problem. Boyle said that many dive as deep and suffer as much cold as those who bring up pearls. It is not necesary to attempt a solution of an universal problem. Meyer spoke of gaining gold from rubbish.

Many have not the time—men in New York often gain their recreation simply in change of work. Research may even become a recreation. Truly it is a habit differing from most habits in that it is easily lost.

I have been through a very rigorous school of experience and have a keen appreciation of the many sides of the problem of research in its relation to the teaching profession. What I have

to say comes from the heart of one who knows, one who has been confronted with the difficulties of want—poverty of apparatus, poverty of time—and I would help as I may to facilitate the deserving idea of your worthy chairman.

THE TEXT-BOOK AND NOTHING MORE.

By Otis W. Caldwell,

State Normal School, Charleston, Ill.

In one's teaching experience there often appear illustrations of the differences in ability between those students who have been accustomed to obtain their knowledge from definite assignments in books, and those who have derived some of their knowledge through experience with materials. The recitation, when solely from one text-book, is often conclusive and "settles things," and possibly sounds better to some pupils, teachers and visitors than do recitations into which are injected the varying reports of pupils who have observed varying phenomena. To both teachers and pupils it often gives greater immediate satisfaction to study and recite solely from books. The assignment has definitely set limits, and the pupil feels that he knows when he has prepared all his lesson. He may come to the class with a feeling of certainty that he has compassed the materials assigned to him.

On the other hand the student who had studied from illustrative material rather than from books exclusively, may be much less certain that he is prepared, though he often has a more efficient knowledge of the subject under consideration. He has observed, and in trying to come to conclusions warranted by his observations, has been compelled to recognize numerous variations in the materials studied. He recognizes that the same materials at different times present different phenomena, and thus has emphasized to him the difficulty of making definite interpretations. Such a pupil not infrequently discovers that text-book statements are sometimes nothing more than loose generalizations, and cannot be made to fit exactly the varying specimens of which these statements are supposed to be true.

It is important in this connection to take account of the fact that when out of school the pupil's experiences are not to be of

the text-book nature, but of the nature of a first-hand study of diverse phenomena. In business, law, and elsewhere, men are constantly encountering new combinations of phenomena, and must learn to interpret them. Many business men sneer at the idea of a college education for a prospective business man, because so often, they claim, it gives him a bookish notion of subjects that do not enable him better to encounter a new situation and properly interpret it. More training in observing and interpreting our experiences and less in methodically learning and reciting lessons would develop greater mental strength and usefulness, more accurate knowledge and less dogmatism.

The learning and reciting of lessons from text-books is necessarily an essential part of school work, but becomes most profitable when properly related to experience other than that had with the text-book.—*The School News and Practical Educator.*

ARE ATOMS DIVISIBLE?
By Arthur A. Skeels.
West High School, Cleveland, Ohio.

Although we cannot hope to answer the above question by direct observation, there is a great amount of evidence to show that our so-called atoms are by no means the smallest particles of matter. The limits of this paper will permit but a brief outline of some of the simpler forms of this evidence.

Nothing is more firmly fixed in the scientific world than the divisibility of matter down as far as the atom. But why should we say that this divisibility ends here? We ought to have the strongest kind of evidence to justify us in an attempt to stop thus abruptly one of the best known plans of nature. Logically, unless some good evidence to the contrary be forthcoming, we should consider that the same structure of matter that exists above the atom should continue to exist below the atom. That is, that in the same way that the molecule is a group of smaller parts we call atoms, so is the atom a group of still smaller parts we may call subatoms. Furthermore, that these subatoms are groups of yet more minute parts we may call sub-subatoms, etc., etc. Also, that in the same way that we have ordinary solids, liquids and gases, made up of particles

(molecules) consisting of groups of atoms, so do we have sub-solids, subliquids and subgases, made up of particles consisting of groups of subatoms. Furthermore, that we have sub-subsolids, sub-subliquids and sub-subgases made up of particles consisting of sub-subatoms, etc.

We are not content, however, to base this structure of matter below the atom entirely on analogy with the structure of matter above the atom. We will try to point out that many phenomena, otherwise unexplainable, can be explained logically and consistently by means of this structure of matter.

For the sake of clearness, we will take up particular and definite phenomena.

Let Figure 1 represent the atom of oxygen, consisting of a group of subatoms of various masses and densities. This figure and others that follow are to be taken as diagrams only, and are not intended to represent accurately the relative shapes and sizes.
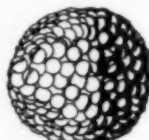
Fig. 1.

Gravitation alone within the atom would cause these substances to collect to an approximately spherical group with the densest subatoms at the center. But at the time of the formation of the atom, outside attraction, centrifugal force or both, caused a variation in this arrangement, and drew the densest subatoms to one side, as shown by the shaded portion of the figure. Two oxygen atoms "a" and "b," as in Figure 2, with their dense sides together will have a much stronger attraction for each other than for any other atoms of oxygen, as "c" or "d," whose centers of mass are farther away. Hence, two oxygen atoms form the most stable group, the ordinary free oxygen molecule.
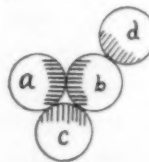

Fig. 2.

In a similar manner we can explain why the ordinary molecules of hydrogen, chlorine, nitrogen, etc., consist of two atoms.

Although the atoms have a strong attraction for each other, the molecules have comparatively little attraction for each other

on account of the distance apart of the centers of
mass, Figure 3.   That is, at a very low tempera-
ture only, will they collect indefinitely to form a
liquid.   A similar condition exists in the case
of hydrogen, nitrogen, etc.

Fig. 3.

Oxygen and hydrogen gases will ordinarily
mix without combining, for even under the most
favorable conditions the molecules have their centers of mass
too far apart for sufficient attraction to form a stable group,
Figure 4.

But if the temperature be raised so the oxygen
molecule is broken up into separate atoms, then
the hydrogen molecules can get close enough to
the oxygen atoms. Figure 5, to form the stable
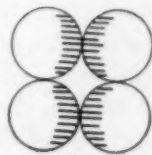
Fig. 4.
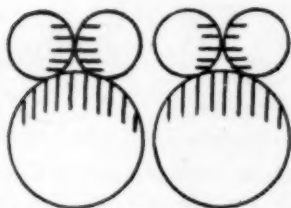
water molecules, while the fall in
potential energy from the position of
Figure 4 to that of Figure 5 is mani-
fested in kinetic energy, or, as it is
usually termed, the heat of com-
bustion.

Fig. 5.

When electric sparks pass through
free oxygen gas, some of the mole-
cules are broken up, and when the
atoms afterward rush together, a few of them come together
as in Figure 6, forming the molecule of ozone.   These atoms
are, however, in rather unstable equillibrium, a
comparatively slight disturbance will break up
the group, two of the atoms will unite to an
ordinary oxygen molecule, and the third will
be left in the single form, with its dense side ex-
posed. ready to strongly attract any other atom
which may happen to be near.   That is, ozone
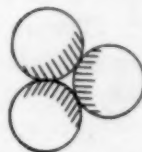is a strong oxidizer.

Fig. 6.

In fact any process which leaves the oxygen atoms in the
single or nascent form, leaves them in a form to combine more
actively with other atoms or molecules.

In the chlorine atom there is a dense portion near one side,
but it is smaller in extent than that of oxygen,

as is shown by the fact that while under ordinary conditions the oxygen atom will hold two atoms of hydrogen, the chlorine atom will hold but one, as in hydrochloric acid, Figure 7. Although the atoms in the molecule of chlorine

Fig. 7.

have more than twice the mass of the atoms in the oxygen molecule, they do not attract each other so strongly on account of the greater distance apart of their centers of mass. That is, the molecules of chlorine are more easily broken up into separate atoms; hence, it combines with other atoms more easily than oxygen. While, on the other hand, the greater mass of the chlorine molecules gives them more attraction for each other, and hence they form a liquid at a higher temperature.
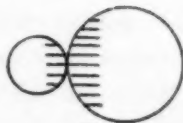
In the nitrogen atom the dense portion is still larger than in the oxygen atom, as is shown by the molecule of ammonia, where the atom of nitrogen holds three atoms of hydrogen, Figure 8. This larger dense portion brings the centers of mass of the atoms in the nitrogen molecule still nearer together, and makes it more difficult to break

Fig. 8.

up than the oxygen molecule; hence, oxygen is more active than nitrogen, for in general the molecule must be broken up before the atoms can unite with others.

Atoms of other elements may have dense portions large enough to hold four or more atoms of hydrogen or an equivalent, that is, the valency of an atom depends upon the extent of this dense portion.

The atom of phosphorus, Figure 9, has a dense portion of larger extent, but of less density than nitrogen, since it will hold an equivalent of five atoms of hydrogen, but have a less attraction for each other, since the phosphorus molecule is easily broken up. Moreover, this dense portion is denser at "b" than at "a." If there is an excess of the combining substance, the equivalent of three

Fig. 9.

atoms of hydrogen are held at "b" and two at "a," but the two at "a" are less strongly attracted and are easily dislodged, leaving the three at "b." This variation in the density of the dense portion explains how an atom may apparently have two valency values.

Four atoms of phosphorus unite to form the elementary molecule, Figure 10. Evidently the attraction along the axis *"ab"* is greater than along the axis *"cd,"* so that as the temperature rises it first breaks up into two molecules of two atoms each, as is shown by the change in vapor density.

Fig. 10.

The subatoms in the atom of ordinary phosphorus are rather loosely held together. Under the proper conditions these subatoms draw more closely together to form the denser atom of red phosphorus. These atoms now have a stronger attraction for each other than before, thus making the molecule more stable and less easily broken up; that is, red phosphorus is less active than ordinary phosphorus. Also these denser molecules have a greater attraction for each other; hence, red phosphorus is less soluble than the other. Under the action of lead a still further condensation of the atom causes its density to approach that of metals, and gives rise to the so-called metallic phosphorus.

When hydrogen is absorbed by palladium the hydrogen atoms become denser and assume metallic properties which are not shown by solid or liquid hydrogen, because the atoms of the latter consist of subatoms loosely held together. Solid or liquid hydrogen bears the same relation to hydrogenium that ordinary phosphorus bears to metallic phosphorus.

A further study of the chemical properties of matter, which lack of space will not permit here, will add more and more to the evidence that the atom is a group of subatoms.

(Continued in the November number.)

AN EXPERIENCE AND A REFLECTION.

By B. W. PEET.

State Normal College, Ypsilanti, Mich.

A few years ago I had an experience on this wise. I was examining the credentials of a large number of high school graduates from different parts of the country, and, incidentally, asking them some questions, when I, by accident, let my knife drop on the floor. Casually I asked one of the number what made the knife fall. "The force of gravity made it fall," he said. I asked others and got always the same reply. I continued the investigation for some time and in many places, until I became sure that whatever a high school graduate may know or not know he is at least sure of this, that it is the force of gravity which makes unsupported bodies fall. Not one had the courage to say that he did not know; not one had the sense of reality to say that the very visible and tangible earth had anything to do in the case; not one had that particular wheel in his head that made him urge that cause is always personal, and that I made the knife fall by releasing my hold upon it. And I found that this form of speech was all but universal. A wagon was not pulled by a team of horses, but by the force of the team. A freight train did not consist merely of an engine and loaded cars; a third thing, as real as either of the other two, the force of the locomotive, must be added to the dramatis personae. And it seemed to me that this excessive use of abstract terms was far too prevalent, even among children, to whom realities are so dear. Even children in the primary school knew more about "matter" than they did about air and water and iron and stone; more about energy than they did about work; more about molecules than they did about grains and drops and particles. I remember among other things that I inquired of a primary teacher whether she was accustomed to include any work in physics in her course of lessons in nature study, and that she replied, "O, yes; we have two lessons upon matter, two upon molecules, two upon force and four upon energy." And certainly one may be permitted to hope that when the children have peopled the landscape with these creatures life will be more interesting to them.

Now it is possible that we ought to commend this tendency

toward the general and the abstract instead of condemning it. Certainly no one can know much of what is going on around us without this process of generalization. Some word to represent all the pushes and pulls in one's experience tends to economy of time and thought. But how if there are no particulars behind the general? And, moreover, it is easy to see how this tendency to extensive use of general terms comes about. The text-books all begin this way; they must do so. Their order is necessarily de-. ductive; the order of holding and stating truth rather than of discovering truth. They must begin with the most general terms and proceed in the course of the treatise to analyze them into particulars. And it is so easy to follow the order of the texts instead of getting the appropriate material for study.

But, however, it comes about, this tendency toward the very early introduction of general terms is apt to be deprecated. When a boy sees a locomotive hauling a loaded train and discovers a third thing, called force, as real as the other two, and, dismissing the locomotive, affects to haul the train by it, he is on the road that leads straight to the hell of confusion and vacuity. Generalization is not only proper and important, it is necessary to the progress of inquiry, only one does so long to find some stage of education where the pupils deal with things in particular.

THE MEANING OF THE FORMULA $F = ma$.
By G. W. Stewart.
University of North Dakota.

A recent article in the May number of this magazine by Professor Crew, "A Neglected Point in the Teaching of Elementary Dynamics," has no doubt been read with interest by many teachers. He says, "In terms of the usual algebraic symbols the defining equation of force is

$$F = ma.$$

But if this be granted how is one to justify himself in saying that force is required to maintain a constant elastic deformation, where no acceleration of any kind is involved? This is the difficulty alluded to in the title of this note."

I have just examined twelve books, selected at random. Six of these were written for colleges, and six for secondary schools. In only one of them do I find the difficulty eradicated, and in that one, a college text, the explanation of the equation lacks sufficient emphasis. I am quite sure that this laxity in our texts must needs mean a lack of clearness of conception on the part of many teachers and pupils. The student learns from the text book that any force F acting on a mass m will produce an acceleration a, the relation being expressed by the formula $F=ma$. Let him apply this conception to the case of an elevator of mass m, descending with an acceleration a, the tension T to be found, and he is at once confused The confusion is caused by wrong teaching. The student has not the meaning of the equation. His idea of m and a are probably correct, but the exact meaning of F is the stumbling block.

F is the force that actually produces the acceleration, $i.\ e.$, it is the *unbalanced* or *resultant* force.

As simple as is this interpretation of F, I fancy most students must either flounder upon it or never understand the use of the equation. On the other hand, a student that has been correctly taught will at once search for the *resultant force* in a problem presented him. For example, the solution of the elevator problem resolves itself into finding the resultant force, $i.\ e.$, the difference between the force acting downward, mg, and that acting upward, T, and then equating this resultant force, $mg - T$, to the mass times the actual acceleration. From this equation T is easily found. (Here $g=980$ dynes, and mg is the number of dynes acting on m grams.)

Probably the writers of the text books I have examined expect the student to assume that the force F is free to act, that is, is not opposed by another force. However this may be, I am sure that most students are unable to apply the formula correctly without an interpretation similar to the one I have given.

THE ELEMENTS OF CIRCULAR MOTION.

By Francis E. Nipher.

Professor of Physics in Washington University, St. Louis.

There are few ideas that are more difficult for a student to grasp than the proposition that a body moving uniformly in a circular path, is moving continuously towards the center of the circle, with uniformly accelerated motion. This proposition may be explained as follows:

Fire a rifle ball horizontally. If not acted upon by forces other than the gas pressure in the gun, it would move on forever in a straight line tangent to the earth's surface. The earth's pull drags it to the ground. Give it greater and greater initial velocity. If the velocity could be made great enough, it would go around the earth in a circular path. Neglecting air resistance, its motion would still continue forever. The earth's constant radial pull of *mg* dynes, added to the continuous tangential straight line motion gives a circular path as a resultant. If the tangential motion did not exist, the body would fall radially, with uniformly accelerated motion. That radial fall, superposed on the uniform tangential motion, gives uniform motion in a circle.

The moon is such a body. The mass M in the apparatus of Professor Crew, shown in the May number of this journal, is such a body. In that apparatus, the spring exerts the radial pull and produces the radial acceleration towards the center of the circular orbit.

The mathematical discussion of circular motion involves only the simple algebra of the High School. I venture to give it in a form which seems clearer than that given in the text books.

The velocity V in a tangential direction, which we may suppose was initially given to the bullet or to the moon, would in t seconds after starting, carry it in a straight line over a distance

$$d = Vt \quad (1).$$

We will suppose that t is a very minute time interval.

During t seconds the body is continually falling. The distance fallen through is

$$h = \tfrac{1}{2}gt^2 \quad (2).$$

As a result, the body moves over a diagonal path with uniform velocity v. In t seconds it will actually travel a distance

$$s = vt \quad (3).$$

The shorter the time interval t the more nearly may the path s be considered a straight line, such that $s^2 = h^2 + d^2$.

Eliminate t in (1) and (2). We have

$$h = \tfrac{1}{2} g \frac{d^2}{v^2} \quad (4).$$

Eliminate t in (1) and (3). We have then by squaring the resulting equation

$$s^2 = v^2 \frac{d^2}{v^2} \quad (5).$$

Eliminate $\dfrac{d^2}{v^2}$ in (4). and (5).

$$\frac{s^2}{2h} = \frac{v^2}{g} \quad (6).$$

Fig. 1 represents the orbit described, having radius r, and shows the small distances d, h and s. By similar lar triangles in the figure

$$\frac{h}{s} = \frac{s}{2r} \text{ or } \frac{s^2}{2h} = r \quad (7).$$

Putting this value in (6)

$$g = \frac{v^2}{r} \quad (8).$$

Here v is the velocity in arc. Let T be the time in which the body describes the circle of radius r, whose circumference is $2 \pi r$. Then

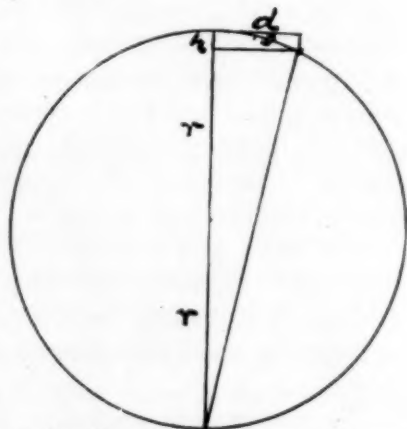$$2 \pi r = v T \quad (9).$$

Eliminating v in (8) and (9)

$$g = \frac{4 \pi^2}{T^2} r \quad (10).$$

or solving for T

$$T = 2 \pi \sqrt{\frac{r}{g}} \quad (11).$$

Equation (11) considers the revolving body as a pendulum, and gives its time, in terms of radius r, and radial acceleration g.

Example. The mean radius of the earth is $r = 637,000,000$

or 6.37×10^8 cm. The radial acceleration of a falling body at its surface is $g = 981$. By (8) the velocity that must be given the bullet at the earth's surface is

$$v = \sqrt{gr} = \sqrt{6.37 \times 10^8 \times 981} = 2.50 \times 10^5 \; cm \text{ per second}$$

This is 4.91 miles per second. The time in which it would go around the earth is by (11)

$$T = 2\pi \sqrt{\frac{6.37 \times 10^8}{981}} = 5059 \text{ seconds}$$

This is one hour and twenty-four minutes.

Example. The time T in which the moon revolves in its orbit around the earth is *27d 7h 43m* or $T = 2.361 \times 10^6$ sec. The radius of the moon's orbit is 240,000 miles or $r = 3.861 \times 10^{10}$ cm. These two values in (10) give as the radial acceleration of a falling body at the moon's distance from the earth, $g = 0.273$.

Example. By Newton's gravitation law the acceleration of a falling body varies inversely as the square of the distance from the earth's center. The distance of the moon is 60 radii from the earth. Hence the acceleration there is found from the proportion

$$\frac{g}{981} = \frac{1^2}{60^2} \text{ or } g = 0.273$$

This agrees with the value found in the preceding example.

Example. If the moon were to be stopped in its tangential motion, it would be necessary to hang it on a steel cable, as a plumb bob, in order to keep it from falling upon us. The weight of the moon would be

$$W = m g.$$

The mass of the moon is $\frac{1}{80}$ the mass of the earth or $m = 7.67 \times 10^{25}$ grams. Hence the steel cable must carry a load of

$$W = 7.67 \times 10^{25} \times 0.273 \text{ dynes.}$$

Dividing this by 981 we reduce it to grams weight at the earth's surface. The result is in kilograms weight 2.13×10^{19}. A steel rope will carry a load of 54,500 Kgr. per square inch of cross-section. The cable to carry the moon must therefore have a cross-section of 3.91×10^{14} square inches, or a diameter of 350 miles.

A CONVENIENT COPYING STAND.

By Fred A. Holtz,

State Normal School, Mankato, Minn.

In copying pictures by photography a serious difficulty is the adjustment of the camera for height and distance from picture. To copy with the camera on a separate stand or its own tripod is bothersome, and it is not easy to get the axis of the camera to hit the center of the picture and have it square to the picture at the same time.
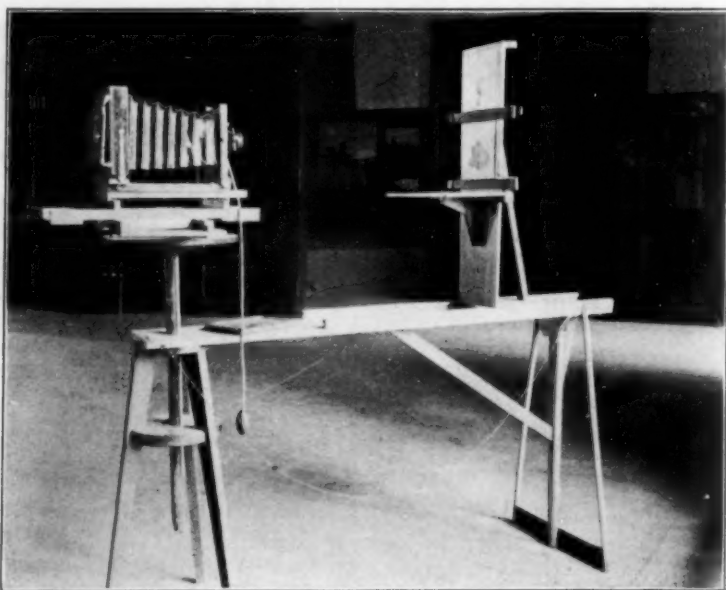

The accompanying photograph shows a simple and convenient stand to reduce this difficulty. It is easily constructed. The camera is placed on a double sliding frame capable of lateral and forward and back motion. There is also a vertical swing arrangement for paralleling the plate edges with the picture's.

The adjusting frame is hinged in front to a narrow board which is firmly screwed to the elevating table. This elevating table will be recognized as a galvanometer stand. A horizontal board, about five feet long ,with a rabetted groove on each side, is fastened securely to the base of the elevating table, at right angles to the axis of the camera, and is supported at the farther

end by firm legs. A block slides along this grooved board and carries a vertical easel board.

Gross adjustment for distance is effected by sliding the easel back or forward by means of strings which lead to the operator behind the camera. Gross adjustment for height is done by means of the elevating table, which is prevented from revolving by a narrow strip tacked to its stem and sliding in a notch in the base of the table.

The finer adjustments for distance and alignment are made by means of the sliding camera base. For slight changes in elevation a thumb screw is turned under the back of this base, which does not noticeably distort the image. If the lines of the picture are not parallel with axis of the plate this can be corrected by slightly turning the base board of the camera (f in the diagram) and securing in position by means of the set screws s.
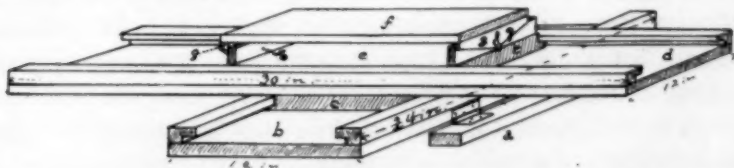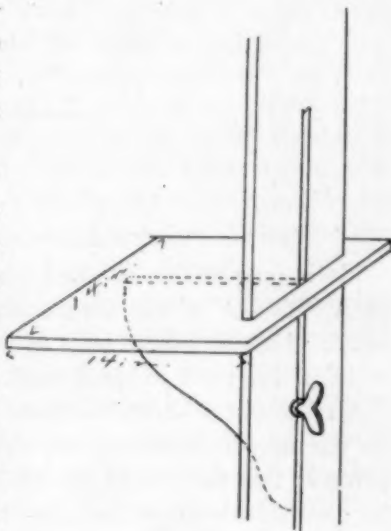
There is a sliding shelf on the easel. The easel slides through an opening at the back of the shelf, and the shelf can be clamped by a thumbscrew in the shelf prop. This thumb-screw slides in a slit in the easel. Pictures and books are clamped to the easel by means of strips of wood held together with rubber bands.

The accompanying diagrams indicate clearly the details of construction. If lightness is desired the double sliding frame may

be made on the skeleton plan. This is as shown in the photograph, but the plan is essentially as indicated in the diagram. To ensure easy sliding, rub a little paraffin on the sliding surfaces.

For enlargements it is necessary to clamp an extra length to the camera base to support the extension bellows.

Science teachers making lantern slides will find this or similar device invaluable in their work. After the picture or object is once placed on the easel, all further adjustments may be made from the rear of the camera

ON SCIENCE TEACHING. I.

By C. R. MANN,

Ryerson Physical Labratory, University of Chicago.

It is only within the last few years that the hitherto latent possibilities of science instruction have begun to become recognized. That they have been as yet wholly unrealized even in the work of the most inspired teachers is—alas—a too painful fact. For all teachers—certainly those of us who have pondered much on our opportunities and our achievements—must have come to perceive that the results of our labors, though partially satisfactory and oft-times encouraging, fail somehow to satisfy our inner consciousness or to make us think that we have advanced very far towards our ideals.

The teacher is assuredly not alone in this. For in these days of the restless development and the rapid expansion of our thought life and our ideals, it is natural that our attainment in all directions should find it difficult to keep pace with the advance. Yet the teacher of Natural Science seems to occupy a particularly difficult position, because, besides meeting the general conditions just mentioned, he has also to deal with a subject that is young and growing on the material side at an extraordinarily rapid rate. Hardly a month passes in which some new discovery is not announced or some new theory brought forward. How can he ever keep track of it all, let alone introducing it effectively into his instruction?

This is a question that every science teacher must face and answer for himself. No two teachers are ever placed in the same circumstances or ever have the same conditions to meet. There-

fore, no final answer can be given to it. It may, however, help us all in finding our own solutions if we can make our vague ideals concerning the actual and the possible functions of science instruction clearer and more definite—for no teaching can be forceful unless guided by definite aims and a clear understanding of the ideals toward which it is striving.

From the teacher's point of view perhaps the most important notion in physical science is that attaching to the word "exact." Physics, for example, is always spoken of as an "exact" science, and this term is popularly construed to apply to everything about it, its methods, its theories, its measurements, and its results. It is, however, of vital importance to the teacher to have a clear conception of the limits to the use of this word when applied to this subject. In how far are our observations exact? When are our methods exact, so that they lead to exact conclusions?

Everyone will agree that our observations are never exact, else why are we continually fussing about percentages of error? And yet nine-tenths of all scientists will agree that the law of the equilibrium of the lever, for example, is strictly exact. But if this result is obtained from approximate observations, how can it be more exact than the experiments on which it is based? Consider how the law is obtained. Suppose you are trying to lift a heavy stone by means of an iron crowbar. The pressure exerted by your hand strains the bar so that its particles are brought into a new series of relationships with one another, some being pushed closer together, some pulled farther apart. The prop or fulcrum on which the bar rests is dented and its particles deranged in an incomprehensible way. Similarly a vast series of changes is produced in the stone near the place where the crowbar touches it. In short, in this apparently simple experiment you are dealing with a vastly complex series of phenomena. To understand or solve the problem in its entirety, would be to fathom the mysteries of the Universe.

In the face of such a problem the scientist closes his eyes to the details of the actual phenomena, goes to the blackboard, makes a geometrical diagram, and says: "Let the straight line ABC represent the crowbar; B, the fulcrum; and the vectors AM and CN the two forces, etc." Then, with the assistance of the principle of

virtual displacements, the geometry of figures, and the work principle, he proves the "law" of the lever. The law thus derived is exact—at least as exact as are the principles or definitions or axioms that were used in its proof. Thus the law is exact not because of the accuracy of our observations of the corresponding phenomena, nor yet because of our hopeless inability to comprehend the objective reality, but simply because or our power of abstracting the actual into a geometrical diagram or an algebraic equation. Since this abstracting process is an act of the human mind, it appears that the accuracy of scientific laws depends in large measure on our own mental activity.

The development of the atomic theory of matter furnishes a capital example of the play of these human powers of abstraction. To Democritus, Lucretius, and Newton, the atom was a smooth, hard, indivisible, material thing. But Pére Boscovich abstracted it into a "center of force," and the modern physicist has shown by mathematics that a vortex in a perfect, i. e., a physically inconceivable—fluid or plenum may have the properties that the atom is supposed to possess. This latter theory is a pure mathematical abstraction, since the medium in which the vortices twirl must have properties that render it physically inconceivable: Thus matter has become non-matter in motion.

A similar fate has befallen mass. Although scientists were unable to define it so long as they retained any notions of substance connected with it, yet the latest definition, namely, that mass is a coefficient in an algebraic equation, is certainly a masterpiece of mathematical abstraction

All this reminds us of the Cheshire cat in Alice's Adventures in Wonderland, which "vanished quite slowly, beginning with the end of the tail, and ending with the grin, which remained some time after the rest of it had gone. "Well, I've often seen a cat without a grin," thought Alice; "but a grin without a cat. It's the most curious thing I ever saw in all my life."

A failure to realize the great role played by this abstracting process in science seems to be the source of a large number of our shortcomings as teachers. For example, if an instructor has once clearly grasped the fact that the so-called principles and laws of science derive their final accuracy from our powers of abstrac-

tion, can he confine the student's attention so assiduously as is often done to a percent, and percents, and half a percent of error? Far be it from us to decry the importance—nay, the vital necessity —of such considerations of accuracy in advanced research work. But do we not sometimes forget that the high school pupil is not a research specialist, and that he is as a rule not enamored of great accuracy? Do we not then develop rather his manual dexterity than his reason and his imagination?

In our eagerness to have well equipped and "thoroughly modern" laboratories, do we not often fail to make use of the vast fund of physical experience which everyone necessarily possesses simply because he has lived on this planet? Yet we often reject, in whole or in part, this fund of real experience—experience gained by having lived it so that it is part and parcel of our beings —and expect to develop a system that shall be comprehensive and exact on the basis of comparatively few rather clumsy stock experiments with half a hundred percentages of error thrown in for good measure.

But the real vitality of Physics is not in these external signs and symbols—this tinkling brass—but rather in the human part— the scientific imagination; and any student who leaves his physics class for the last time without ever having felt an inspiration to ponder over and to try to form images of the operations of the world forces amongst which he lives, has been filled with husks and empty forms and dwarfed in soul and mental growth.

Another of the serious errors—an error whose percentage is over 99—into which this idea of "exact" has lead us is that implied in the words "fixed and changeless." For it is so easy to transfer these words from the operations of Nature to the descriptions of these operations as contained in scientific laws. Can we not keep clearly before us the fact that these laws are the production of man and that they are therefore at best incomplete and fallible? The Roman law was living and the soul of the Republic and of the Empire until it was "fixed" by Justinian. It was then what has been justly called the "Justinian Mummy," and the Empire soon fell. The Christian religion was a burning, living inspiration to the early Church until it became "fixed" in a mass of dogma; and then, behold the Inquisition and the Reformation. It is none other-

wise with physical laws. When we "fix" them into a system of dogma, develop them into a logically perfect series, and then dole them out to growing, living, thirsty souls at the rate of so-and-so many pages a day, we are but exhibiting to them a veritable "physical mummy" and should not be surprised if the children turn from it chilled with indifference rather than warmed with enthusiasm.

Whenever we, either consciously or unconsciously, thrust upon a human being the idea that here at last we have something final and exact, we are lending our aid to the powers of death. For how does science grow? How are its new discoveries made? Does not every man in silence in his own soul construct his own world from the materials which he gathers in his lifetime? And what guides him in the building of it? Should it not be his own imagination—his own personal judgment acting in freedom? Should not his world then be an image of his personality? And are not all great things brought about by men of marked individuality—of powerful personality? But if in physics, or in anything else for that matter, we present to a growing mind a fixed system of thought—a mummy of any kind—will it help or hinder the free development of that greatest of human prizes, individuality? Will we be joining hands with the heroes of humanity in trying to establish yet more firmly the recognition of the inalienable right of every individual to absolute freedom of personal judgment; or shall we be secretly fostering intolerance? And intolerance has been powerful enough to cause the most powerful organizations to ruin themselves in their madness.

Clearly then the best teacher is he who keeps the path before the growing personality most open—who presents the facts, the theories, all the materials of instruction in such a way as to leave the individuality of the student free to act in silence in its own sweet way. It is the particular glory of science that this inner freedom is her heart and soul. A truly scientific judgment cannot be made unless the mind is wholly free. Let him who would tread on this inner freedom beware, "for the place whereon thou standest is holy ground."

The practical application of the principles just discussed must be worked out by each teacher in accordance with his own partic-

ular surroundings. Only the most general advice can be given to all. The most essential point is to ponder well the principles discussed and be sure that they are clear and well understood. Then bring before the students the materials of science, its facts and its theories; illustrate them carefully by experiments and the experiences of daily life; but be careful so to order and present them that each learner is free to build them into a world of his own. Above all, never let the young mind get the impression that what you give him is final, and never intrude upon his silence when he is engaged in the process of designing and constructing his world concepts. Advise and admonish him and call his attention to contradictory evidence when he seems to go astray, but never insist as a matter of authority that he is wrong. If you cannot make him conclude freely that you are right, leave him alone, for erroneous impressions are often of great value in learning science, and if you are right he will see it eventually.

The skill and the opportunity of the teacher, then, lies in the way in which he presents facts and theories; and his power and success often depends more on that which he leaves unsaid than on that which he says. The greatest error of most of us is, perhaps, that we say too much. Our redemption will be attained and our tremendous power fully realized only when we have learned to subdue ourselves and to let the truth possess the children from the things themselves. Our mission is simply to call their attention to the things of Nature and to the thought of men about those things; and when that is done, we should step aside and thus leave the growing personality of each and every one of them free to construct its individual world in a way that we comprehend as faintly as we do the original building of the objective world about us.

A SIMPLE STEP-UP AND STEP-DOWN APPARATUS.

By DeForrest Ross,
Ypsilanti High School.

The above heading, though not a misnomer, covers only a part of the possibilities of a simple and inexpensive device. As many of the high schools are now equipped with the alternating current for lighting purposes, it occurred to me that this current might be

used for demonstration work in the physical laboratory. The electric magnet before you is the outgrowth of that idea, suggested by some experiments of Prof. Carhart at one of our physical conferences.

First, then, is to make the magnet, as, so far, I have been unable to find anything in the market that will answer the purpose. Procure of your hardware dealer twenty to twenty-five pounds of No. 16 annealed iron wire, and cut it into pieces about fifteen inches long. Bind these in a compact bundle with electric wire tape, and make the top level by driving the wires down with a hammer. This will constitute the core of the magnet. Fasten the core to the base in an upright position by cutting a hole in a board just large enough to admit the end of the core. Bend enough of the wires over around the outer edge to hold the core firmly in position and fasten them to the under side of the board with staples. Then by driving wedges between the wires, the core can be made to stand rigidly in its place. Nail another board on the under side to cover up the uneven ends of the core and it is ready for winding.

Begin at the bottom and wind in smooth close coils four layers of No. 12, double covered copper wire, to within one inch of the top and fasten the ends to binding posts in base. The whole coil should now be covered with electric tape.

Several coils of well insulated copper wire should be made, varying in size of wire, diameter of coils, and number of turns in each. These should be fastened with tape for convenience in handling, leaving the ends long enough for connections.

With a coil of fifty or sixty turns of No 12 copper wire wound so as to fit rather loosely the primary coil, the terminals connected by a No. 16 copper wire, and the coil lowered to the center of the magnet, an induced current will be produced strong enough to quickly fuse the wire and cause the copper to boil like water. Iron wire between the terminals will burn with brilliant scintillations. The operator, however, can hold the naked terminals in his hand without feeling the slightest effects of the current. This illustrates in a forcible way a step-down device.

If a coil of five or six hundred turns of No. 20 wire be used, the potential comes so high that it will make an electric lamp glow

intensely, and by attaching handles to the terminals and slowly lowering the coil from some distance above the magnet, a range of physiological effects will be experienced, varying from an almost imperceptible pulsation to that of sufficient strength to satisfy the most ardent. These are only suggestions of things one can work out, once started along this interesting line. You will also be surprised to see the interest your students will take and how much they will get from this, to them, most difficult part of electricity.

SOME POINTS IN THE HISTORY OF GREEK MATHEMATICS WHICH ARE USEFUL IN SECONDARY TEACHING.

By JULIE SERVATY,
School of Education, University of Chicago.

Man at a very early period manifested a disposition to pursue speculative inquiries. This habit of mind, at least that phase of it we are now to consider, appears to have developed first among the Greeks.

Their first attempts were efforts to comprehend the workings of nature, which led to the introduction of abstract conceptions. As soon as these conceptions emerged in their philosophy, they seem to have taken it for granted that mathematical and physical science resulted from relations among these notions. · By carefully examining these notions, they undertook to work back to fundamental notions. Instead of developing their theories by observation, they analyzed and expanded their theories by reflective processes purely.

Thales gives a very early example of this kind of reasoning. He is reported to have been asked, "What is the greatest thing?" To this he replied, "Place; for all other things are in the world but the world is in it." In his geometrical teaching, he presented a number of isolated propositions, arranged in no logical sequence. It has been suggested that the shape of the tiles used in paving floors may have led to his geometrical demonstrations. He contributed the following six propositions, proved them deductively and thus made geometry a subject for study:

(1)   The angles at the base of an isosceles triangle are equal.

(2)   If two straight lines cut one another vertically, opposite angles are equal.

(3)   A triangle is determined if its base and base angles be given.

(4)   The sides of equiangular triangles are proportional.

(5)   A circle is bisected by any diameter.

(6)   The angle in the semi-circle is a right angle.

The proofs he gave to these theorems were deductive, and his distinction as "the founder of the earliest Greek school of mathematics," lies wholly in the deductive character which he gave to this science.

Pythagoras followed the same method of reasoning. Primarily a philosopher, he built his system of philosophy on a mathematical foundation. We do not know what philosophical doctrines were based on his geometrical knowledge, but he knew and taught the substance of what is contained in the first two books of Euclid. He gave to geometry the vigorous deductive character which it still bears, and was the first to arrange the leading propositions into a logical order.

Much more is known about the philosophy which he based upon arithmetic. Having learned in Egypt that number is essential to the exact description of form and formal relations, he concluded that number is the cause of form. To make the vague abstraction more clear, he examined words applied to numbers and the forms which they called up, and then, by imitation, made things share the nature of numbers. The number four, for example, was held to be the most perfect number. Accordingly, he conceived it to correspond to the human soul. Pythagoras confounded first a numerical unit with a geometrical point and then this with a material atom. He took numbers to be the basis of creation. He derived from them explanations of natural laws as well as definitions of abstract terms. Nicomachus, in his *Arithmetical Treatise,* tells the following story which indicates that among the ancient Greeks, even the science of music was an application of numbers, and that the originator of this arithmetical music was Pythagoras:

Walking along the street one day, Pythagoras passed a

blacksmith's shop. His attention was attracted by the musical
relation of the sounds produced by the hammers as they struck
the anvil. He listened for a time, then went in and weighed
the hammers. He found "The one that was one-half the
heaviest gave the Octave, the one which gave the Fifth was
two-thirds, and the one which gave the Fourth was three-
quarters." After this he made numerous arithmetical trials
and at length discovered that if musical strings of equal
lengths be stretched by weights in the above proportion they
produced intervals which were an Octave, a Fifth, and a
Fourth.

This story is inaccurate; for by striking with hammers
of the weights given, one does not produce the intervals given.
But the relation of the forces which stretch the strings is true
and is still the basis of the theory of musical concords and
discords.

The zenith of abstract reasoning was probably reached by
Aristotle. In his discussion of the term *place* be begins by
enumerating a number of ways in which one thing may be said
to be in another such as, "we say a part is in the whole," "the
species is in genus as man is in animal," and finally, "a thing
is in place." He then examines what place is and concludes
that, "if about a body there be another body including it, it is
in place, and if not, not." But Aristotle systematized deduc-
tive logic. Although he was more deeply interested in natural
philosophy than in mathematics, he used the latter to a great
extent as a means of correct reasoning and formulated many
difficult geometrical demonstrations. Thus he rendered great
service to geometry. We also find the first glimmering of
algebra in Aristotle. He was the first, so far as we know, to
use letters of the alphabet to indicate unknown magnitudes.
He did not do this, however, as a means of algebraic calcula-
tion, but merely as a means of formulating statements.

The use of symbols was continued by Euclid. His symbols
were lines; and they were used to indicate magnitudes includ-
ing numbers. By this means, he solved quadratic equations
and performed other operations of universal arithmetic. But
while he used symbols, he confined himself strictly to geomet-
rical conditions—he would not add a line to a square, or divide

one line by another line. Not until four centuries later, do we find a mathematician who truly created a need of symbolism. This was the Semite, Nicomachus.

The main difference between the mathematics of Nicomachus and that of the earlier Greeks, is that he abandoned geometrical demonstrations. He worked out by the aid of numerical illustrations the results already obtained through geometrical methods, and proved from numbers themselves, indicatively, the theories which up to that time had been proved deductively by the geometrician. He drew many analogies between geometrical and arithmetical facts, such as "a square can be divided by a diagonal into two triangles" and that "every square number is the sum of two triangular numbers." (A number of the form $\frac{n(n+1)}{2}$ had been called a triangular number since the time of Pythagoras, 600 years earlier.)

He dealt also with what he called *solid* numbers. For example, the sum of a series of polygonal numbers from one upwards was called a pyramid,—the pyramid being square or triangular according to the order of the polygonal number. The highest of such numbers was considered the base and one was the apex. If one was omitted, the pyramid was truncated. He dealt in a similar manner with cubes, oblongs, spheres, wedges, and other solids This shows that much must have been done with numbers in the interval of 400 years between Euclid and Nicomachus.

In plane numbers Euclid used only the *square* and the *gnomon,* in solids only the *cube,* and in proportions only the geometrical magnitudes. Nearly all that was known of polygonal numbers and solids and proportions must have been worked out by various mathematicians after the time of Euclid and before that of Nicomachus, for the work of Nicomachus contains little that is original, the only important change made by him being that his work was inductive. The main aim of his arithmetic was classification, and all its classes were derived from and exhibited in actual numbers.

At this point, since arithmetical inductions are of necessity incomplete, a general symbolism similar to the ordinary numerical kind became necessary. Geometry was able to provide this within a certain limit; but the propositions in which

Nicomachus and his immediate successors took most delight
were such as these: "All the powers of five end in five,"
"Square numbers are the sums of a series of odd numbers."
The symbols of Euclid could not be employed in demonstrating
such propositions, so that inductive reasoning gradually led
the way to algebra.

(To be continued)

GRAPH WORK IN ELEMENTARY ALGEBRA.*
By F. C. Touton,
Central High School, Kansas City, Mo.

Much is now being said concerning the use of the graph in
elementary algebra. The movement, I believe, is a good one
and deserves at least the careful thought of each algebra teacher.
In this paper I do not wish to advance a new theory but I do wish
to select from the abundant resources a few typical problems
which will serve to illustrate some of the advantages to be gained
through the use of the graph. By request, I shall attempt to put
the thoughts in a form to be used by a teacher in algebra, who
may not be familiar with the higher mathematics.

As soon as work in simultaneous equations in two unknowns
is reached, I believe it wise to teach the fact that an equation of
the first degree in two unknowns always represents a straight line.

After an actual trial of the graph
in the algebra class room, and
that through a number of years,
I am led to believe that there is
no more satisfactory manner to
illustrate and solve some of the
simple equations of the first de-
gree than by the use of the
graph. To find at one time val-
ues for two unknowns is a con-
clusion at which the pupil is de-
lighted to arrive. A similar
process will indicate that two

Fig. 1.

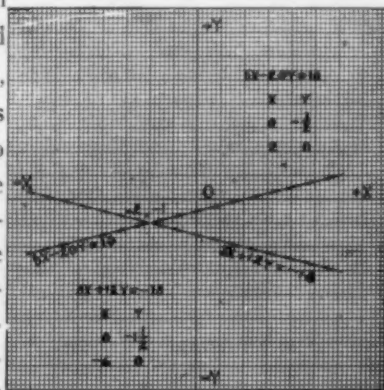equations of the first degree in two unknowns will give graphs,

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*This article is a portion of the paper read by Mr. Touton before the Missouri
Society of Teachers of Mathematics at their first annual meeting.

which if they intersect at all in finite space, can intersect at but one point. The position of this point, common to both lines, will give values which will satisfy both equations. This may easily be seen by plotting the graphs of the equations $5x - 20y = 0$ and $3x + 12y = -18$, as in Fig. 1. The point of intersection, $x = -2$, $y = -1$, will be common to both lines, hence its coördinates will satisfy the equation; another pair such as $x + 2y = 10$ and $3x + 6y = 30$ will invariably give the same straight line, hence the values which satisfy one equation must always satisfy the other.
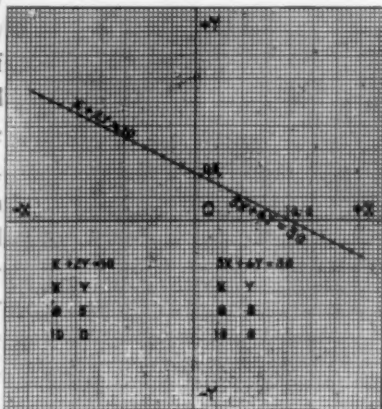
Fig. 2.

Again in Fig. 3, it will be possible to show that independent equations in two unknowns and first degree, as $2x + 5y = 10$ and $4x + 10y = 50$, can have no common values for x and y. This conclusion when reached by the pupil is not questioned, for nothing can be more clear to him than that two parallel straight lines can never meet in finite space. Since the place of meeting determines the values of the
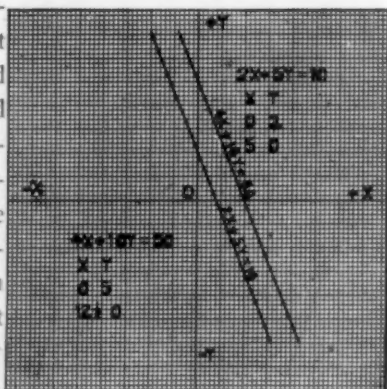

Fig. 3.

unknowns—where there is no common point, there will be no common values for the unknown quantities. Pairs of equations which give lines intersecting in the second, third and fourth quadrants will give an added illustration of value concerning the somewhat intangible negative quantity.

When work in quadratics is reached, the pupil will have no

difficulty in understanding that a
quadratic equation always repre-
sents a curve which can be cut in
two places by a straight line.
He will be interested to know
the nature of the curve which a
certain quadratic equation repre-
sents. When the equations x^2+y^2
$=101$ and $x+y=9$ are con-
sidered, he will be pleased to note
that when plotted, these equa-
tions will give graphs (Fig. 4.)
of a circle cut in two places by
a straight line, at the points (1,
—10) and (—10, 1) respectively,
He will note that the coördinates
of these points will give roots
which will satisfy both equa-
tions.

In a similar manner it will
be found, as in Fig 5, that the
equations $xy = 12$ and $x^2 + y^2$
$=40$) will give graphs of a
circle cut by a hyperbola at four
points. Here the coördinates of
the four points of intersection
(± 2, ± 6) and (± 6, ± 2) will
be the roots of the equations, be-
cause the set equation have two
pairs of double roots.

He will also note that an
equation of the form $4x^2+25y^2$
$=100$ will have an ellipse (Fig.
6) for its graph, while $y=x^2$
(Fig. 7) has a parabola for its
graph. It will be apparent at once
that the graphs of both the ellipse
and the parabola can each be cut

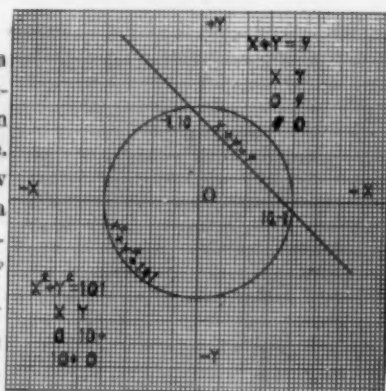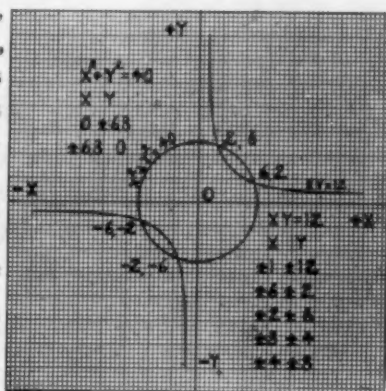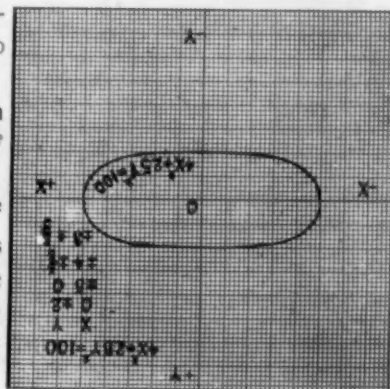

Fig. 4.

Fig. 5.

Fig. 6.

in two places by a straight line.

The quadratic equations will always give rise to a double set of values for x and y. Often in the solution of quadratics the roots will be imaginary. Just here comes up one of the strong points in favor of the graphic representation of points and lines. The pupil is interested to know that it is even possible to plot imaginary roots. To plot the complex number $(-5-8\sqrt{-1})$ (Fig. 8) when (-5) denotes

Fig. 7.

that a distance to be laid off on the x axis five units to the left of the origin while $(.8\sqrt{-1})$ denotes that a distance of eight units should be laid downward on the y axis, passing through (-5) on the x axis, or that the point thus located represents the complex number $-5-8\sqrt{-1}$.

Then, too, the graphic representation of surds is a process of interest to the pupil. The pupil will enjoy the representation of quantities, the exact values of which are usually conceded as impossible. The $\sqrt{5}$ is an incommensurable root, yet in Fig. 9, a distance from the origin to a point located by $x=2$, and

Fig. 8.

$y=1$, will give an exact represented value.

In general, graph work does not need emphasis on the part of the teacher, for interest on the part of the pupil will supply the
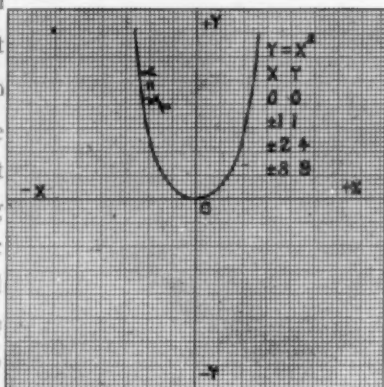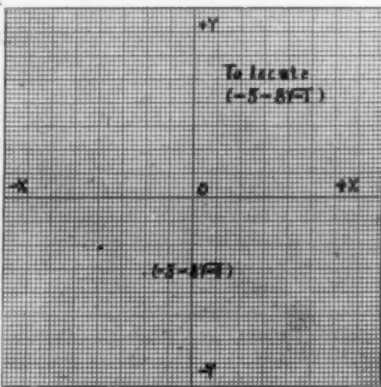
need. The graph work required
that the teacher may successfully
introduce the work into the alge-
bra class need not be extensive
and I believe can be easily mas-
tered by the teacher who has had
no previous training in analytics.
If the graph work is not included
within the range of the algebra
text used, there are several
sources from which the informa-
tion can be secured in pamphlet
form. In the pamphlets I men-

Fig. 9.

tion, the matter is in such a form as can easily be mastered by the
pupil in the study hours. Among such works are the following:

    Graphs, by Aley, D. C. Heath and Company.
    Graphs, by Short, D. C. Heath and Company.
    Graphs, by Nipher, Henry Holt and Company.
    Graphs, by Newson, Ginn and Company.

As to the time to be spent on graph work, I believe that it need
not take the time necessary for the mastery of the other methods
of handling equations. The time will be well spent and I believe
that the solution of equations by graphic methods should at least
be given place along with the other methods of solution for stated
equations.

Of course, we must be careful that the pendulum shall not
swing too far past the center, yet I know that the thoughts pre-
sented in this paper when presented in any algebra class, do incite
interest on the part of the pupil-and at the same time give subject
matter of worth. A test upon graph work in the class room is
always welcome, for the pupils, without exception, like the work.
They will also enjoy the solution of graphic methods of certain
written problems where rates of motion are considered. While I
advocate the use of the graph, I do not intend to take from the
work of any other department nor do I intend to trespass upon
the field of analytics with the first year algebra pupil, but I do con-
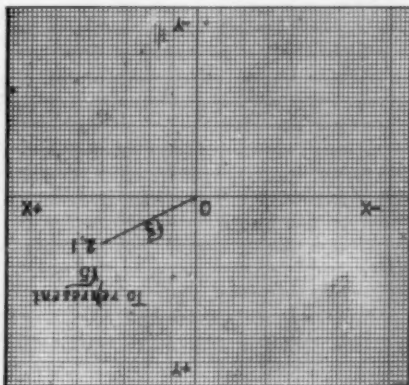tend that the work of the high school algebra class shall be such as

will best prepare our pupils to work with a degree of accuracy and understanding the simple problems he is to meet in his science work.

LIMITS IN GEOMETRIC FORMS.

By Arthur Latham Baker, Ph. D.,
Manual Training High School, Brooklyn, N. Y.

The current doctrine of the text-book world regards the straight line and the circle as two essentially different things. The straight line is regarded as the limit toward which the circle tends, but which it never reaches. So also the circle is regarded as the limit toward which the regular polygon tends, but which it *never* reaches. The theorems regarding the circumference and the area of a circle are derived on the supposition that the circle is the limit which the regular polygon almost but never quite reaches, and that the error is negligible. But we always have the reservation that the circle is *not* a polygon, say what you will, .and that there *is* an error, however small it may be; less than any assignable quantity, but yet an error after all. The difference between the circle and polygon is so small that for all practical purposes we may consider them as one; but, of course, they are not one, and never can be, etc., etc.

And through all this array of verbiage, we feel that there is a fallacy somewhere; it is and it is not, all in the same breath; the error is inexpressible and yet the forms do not coincide. We can push the polygon *almost* to the circle; what is that invisible barrier which keeps it back?

There is no barrier except our own narrow definitions and methods. The straight line is a circle of special form, not the limit of a circle; the circle is a polygon, not the limit of a polygon. There is no residual error. The circle straightens out into a straight line and sweeps over it into a circle on the other side. The inscribed polygon merges into the circle and sweeps over it into a polygon again on the outside.

Let us see what is meant by a limit, and why forms have limits. A limit is that constant value (or form) which a variable value (or form) approaches indefinitely near but never quite

reaches. The test of a limit is $r - x = 0$, and $r - x < i$, where i is any asignable infinitely small quantity.

The subject of limits as taught in the elementary text-books is very crude, and fogged with lack of perspective. In the first place, no distinction is made between the limit in the case of geometric forms (continua) and in numbers (discreta). The two cases are quite different, and the distinction must be recognized.

It seems to be a rule that geometric forms have or have not a limit, dependent entirely upon the method of generation; one method of generation having a limit and the other not, for the same variable. For example, if the angle X is generated by the motion of the intersection A, it has no limit; but if by the movement of the intersection B, its limit is a right angle.
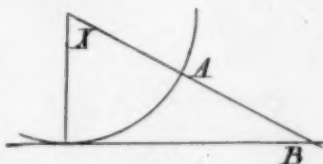
So likewise, if we generate the arc x by the swelling of a cartwheel rim, the limit is a straight line. But if we generate it by the tracing point of a Peaucellier linkage, it has no limit; it straightens out into a straight line and then curves the other way. In both these cases it is the same variable, a line of constant curvature. The elementary text-books blindfold their readers with a, not necessarily faulty, but narrow definition: A circle is a line which always changes its direction, and a straight line is one which does not change, etc. And then triumphantly ask how one can be the other. Throw away the blinders and get a broader view by taking a broader definition; viz., a line of constant curvature, and the contradiction ends.

The old contradiction between a tangent and a secant has begun its evanescence, by considering the tangent as a secant cutting in two coincident points, one double point. But when it comes to swelling an inscribed polygon into a circle, then, they say, the law laid down above fails, since there is no instrument to do the swelling, and however far you continue the process, there are points of the circumference yet unoccupied by the vertices of the polygon. The same objection would have been made in the case of the circle and the straight line previous to 1864, when Peaucellier invented his linkage, showing that the question of a limit does

not depend upon the inventiveness of man; but only our appreci-
ation. Previous to 1864, such an instrument could have been
imagined *in nubibus,* and the same argument used as here, and the
argument would have been just as sound. The only difference
would have been its effect upon the hearers.

Let us look at some examples of limits. (a.) A point mov-
ing half the remaining distance between it and its goal each
second, when will it reach the goal? Never, because between it
and the goal will ever remain the half of some distance. (b.) A
point moving away half the distance between it and a pursuing
point each instant of time, when will the pursuing point catch
the other? Never, because the pursued point is always the half
of some distance ahead. But this is nonsense, for a pursuing
point moving twice as fast as the pursued can overtake it, as wit-
ness the minute hand of a clock and the hour hand.

Now where is the fallacy?

In (a) we have an infinite number of operations stretching out
over an infinite number of seconds and therefore never ended.
In (b) we have an infinite number of operations crowded into a
limited time and therefore completed some time. In (a) the suc-
cession of events is regular but the speed of the moving point is
decreasing to infinite slowness. In (b) the speed of the moving
point is regular, but the succession of events is increasing to infi-
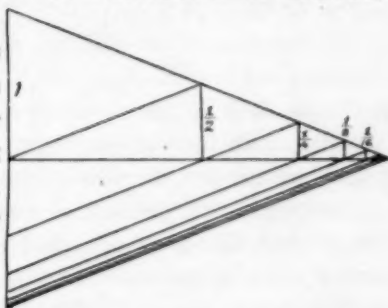nite rapidity.

This shows that the same variable (the distance passed over
by a point moving one-half the preceding distance at each opera-
tion) may or may not have a limit according to the special law
governing its generation. The introduction of a *timed succession*
of events produces a decreasing speed and a limit. A timed
(constant or finite) speed produces an increasing rapidity of suc-
cession of events and no limit.

A horse straining at his halter finds the distance between him
and the door diminished one half each second. Will he get out?
Never! A horse straining at his halter finds the distance between
him and the door diminished one half at each instant of strain.
Can he get out? Certainly! He walks right out the door, just
as the minute hand passes the hour hand. In the first case there
is a timed succession of events. In the second there is a continu-
ous and steady strain, a timed rate of progress—finite speed.

On the other hand, when we come to the summation of the terms of a series, the introduction of the discrete terms seems to take the place of a timed succession of events, and the series has a limit, if convergent.

An illustration of the difference between the summation of *discreta and continua* is given in the series $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\ldots$. If we consider these terms as ordinates erected at finite intervals, the summation has a limit, 2. But if we crowd the ordinates into a triangle as shown, the sum is easily seen by reason of the similar triangles to be exactly 2; and there is no unattainable limit, no residual error. In each case we have dealt with *exactly the same ordinates;* in one case *arranged* so as to have a limit to the sum, in the other case no limit. Which result we shall get is merely a question of arrangement. In this instance the sum of an infinite converging series is a real quantity and not an elusive limit just out of reach. The limit is the *limit of the process and not necessarily any intrinsic property of the variable.*

If we imagine an inscribed polygon swelled toward the circle by doubling the number of sides, etc., the circle seems to be the limit of the operation, for the very process of doubling introduces the timed succession of events which results in a limit. But imagine a process which forced each center of a chord (inscribed square) into a symmetrical position (i. e. on to the circumference of a circle through the undisturbed points) and imagine this kept up at an even speed of surface change. The succession of events increases to infinite rapidity and the inscribed polygons sweep through the circle into circumscribed polygons. The newly produced vertices are arranged on the circumference of the initial circumscribed circle until the circle itself is reached, and then they arrange themselves on circles (of increasing size), the alternate vertices being forced out until the undisturbed ones evanesce on a straight line, and the polygons become of lessening number of sides until the circumscribing square is reached and the process repeats itself into a new circle around this new square, and so on.

Instead of saying "alternate vertices," etc., we might say reversal of the process which produces the circle from the circumscribing square by forcing the vertices inward symmetrically until they evanesce on a straight line, the newly produced vertices being symmetrically arranged. This process kept up at an even speed of surface change sweeps the polygons through the circle and by reversal of the swelling process, into the inscribed square, and so on through a new cycle.

In imagination we can see the polygons swelling into other polygons, the transition figuring between the sets being the circle, as the parabola is the transition curve between the ellipse and the hyperbola. If we imagine the lines to be general lines of infinite length, we can see the plane, initially crossed by the four bundles of lines, gradually becoming more and more crossed until finally the whole plane is crossed and recrossed with lines, except the central circular portion, which is sharply delimited from the rest by the circular boundary which separates the shaded from the unshaded portion. As the process goes on we see the lines coalescing again, the plane becoming less darkened until finally we arrive again at a square, and the process begins over again.

That we have no mechanism for producing these results is of no importance. Until 1864 we had no mechanism which would enlarge the circle into a straight line. Nor have we any now for sweeping the ellipse through its transition curve, the parabola, into the hyperbola. It does not seem likely that we will have. Nor did the Peaucellier linkage seem likely at one time.

To conform to all this, the narrow definition of the polygon and circle must be enlarged. We must define a polygon as a configuration of lines; a regular polygon as a symmetrical configuration, one of the special cases of which is a circle, a symmetrical configuration of an infinite number of lines.

The gist of the matter seems to be that speaking of the limit of geometric forms is merely another way of advertising the fact that we have adopted a process which produces a limit. The limit is *the result of the process* and *not an intrinsic property of the form*. Some other process could avoid the limit. A frequent illustration of this is the historic problem of squaring the circle. In numbers this is impossible because, among other reasons, it is the limit of an infinite series of discrete terms. In geometry, with a

ruler and compass the length of the circumference is also the limit of an infinite series of operations and therefore unattainable. But change the process by using the integraph, and what was before a limit and just out of reach, becomes attainable and we get a line equal to the circumference.

THE MATHEMATICAL HANDBOOK OF AHMES.
By G. A. Miller,
Stanford University, California.

The Handbook of Ahmes was written about 1700 B. C.—more than a thousand years before the beginning of the classic period of Greek mathematics. It stands as an isolated peak in the history of mathematics and practically marks the beginning of this history. It seems to have been written as a compendium of useful and curious mathematical facts for the learned Egyptian priests living at about the time when the Israelites were slaves in their country.

The book is replete with facts of the greatest interest, not only to the students of mathematics, but also to those who are interested in the history of the development of the human intellect. Even the title of the book is naïve. It is as follows: "Directions for obtaining a knowledge of all dark things * * * of all secrets which are involved in the objects." This title gives evidence of the ancient belief in the power and comprehensiveness of mathematical knowledge, and is comparable with the much more recent saying of Isidorus, bishop of Seville, who expressed his admiration of number in his encyclopedia in the following words: "Take away number from all things and everything goes to destruction."

The five parts of the Handbook of Ahmes are devoted respectively to the following subjects: Arithmetic, stereometry, geometry, calculation of pyramids, collection of practical examples. The first part begins with a table in which the forty-eight fractions having two for a numerator and the odd numbers from 5 to 99 as denominators are expressed as sums of different fractions having unity for their common numerator. The table is so curious that we reproduce it here, omitting only the verifications which were given with each fraction.

This table is of great historical importance. It appears that no

$\frac{2}{5} = \frac{1}{3} + \frac{1}{15}$; $\frac{2}{7} = \frac{1}{4} + \frac{1}{28}$; $\frac{2}{9} = \frac{1}{6} + \frac{1}{18}$; $\frac{2}{11} = \frac{1}{6} + \frac{1}{66}$;

$\frac{2}{13} = \frac{1}{8} + \frac{1}{52} + \frac{1}{104}$; $\frac{2}{15} = \frac{1}{10} + \frac{1}{30}$; $\frac{2}{17} = \frac{1}{12} + \frac{1}{51} + \frac{1}{68}$;

$\frac{2}{19} = \frac{1}{12} + \frac{1}{76} + \frac{1}{114}$; $\frac{2}{21} = \frac{1}{14} + \frac{1}{42}$; $\frac{2}{23} = \frac{1}{12} + \frac{1}{276}$;

$\frac{2}{25} = \frac{1}{15} + \frac{1}{75}$; $\frac{2}{27} = \frac{1}{18} + \frac{1}{54}$; $\frac{2}{29} = \frac{1}{24} + \frac{1}{58} + \frac{1}{174} + \frac{1}{232}$;

$\frac{2}{31} = \frac{1}{20} + \frac{1}{124} + \frac{1}{155}$; $\frac{2}{33} = \frac{1}{22} + \frac{1}{66}$; $\frac{2}{35} = \frac{1}{30} + \frac{1}{42}$;

$\frac{2}{37} = \frac{1}{24} + \frac{1}{111} + \frac{1}{296}$; $\frac{2}{39} = \frac{1}{26} + \frac{1}{78}$; $\frac{2}{41} = \frac{1}{24} + \frac{1}{246} + \frac{1}{328}$;

$\frac{2}{43} = \frac{1}{42} + \frac{1}{86} + \frac{1}{129} + \frac{1}{301}$; $\frac{2}{45} = \frac{1}{30} + \frac{1}{90}$;

$\frac{2}{47} = \frac{1}{30} + \frac{1}{141} + \frac{1}{470}$; $\frac{2}{49} = \frac{1}{28} + \frac{1}{196}$; $\frac{2}{51} = \frac{1}{34} + \frac{1}{102}$;

$\frac{2}{53} = \frac{1}{30} + \frac{1}{318} + \frac{1}{795}$; $\frac{2}{55} = \frac{1}{30} + \frac{1}{330}$; $\frac{2}{57} = \frac{1}{38} + \frac{1}{114}$;

$\frac{2}{59} = \frac{1}{36} + \frac{1}{236} + \frac{1}{531}$; $\frac{2}{61} = \frac{1}{40} + \frac{1}{244} + \frac{1}{488} + \frac{1}{610}$;

$\frac{2}{63} = \frac{1}{42} + \frac{1}{126}$; $\frac{2}{65} = \frac{1}{39} + \frac{1}{195}$; $\frac{2}{67} = \frac{1}{40} + \frac{1}{335} + \frac{1}{736}$;

$\frac{2}{69} = \frac{1}{46} + \frac{1}{138}$; $\frac{2}{71} = \frac{1}{40} + \frac{1}{568} + \frac{1}{710}$;

$\frac{2}{73} = \frac{1}{60} + \frac{1}{219} + \frac{1}{292} + \frac{1}{365}$; $\frac{2}{75} = \frac{1}{50} + \frac{1}{150}$;

$\frac{2}{77} = \frac{1}{44} + \frac{1}{308}$; $\frac{2}{79} = \frac{1}{60} + \frac{1}{237} + \frac{1}{316} + \frac{1}{790}$; $\frac{2}{81} = \frac{1}{54} + \frac{1}{162}$;

$\frac{2}{83} = \frac{1}{60} + \frac{1}{332} + \frac{1}{415} + \frac{1}{498}$; $\frac{2}{85} = \frac{1}{51} + \frac{1}{255}$; $\frac{2}{87} = \frac{1}{58} + \frac{1}{174}$;

$\frac{2}{89} = \frac{1}{60} + \frac{1}{356} + \frac{1}{534} + \frac{1}{890}$; $\frac{2}{91} = \frac{1}{70} + \frac{1}{130}$;

$\frac{2}{93} = \frac{1}{62} + \frac{1}{186}$; $\frac{2}{95} = \frac{1}{60} + \frac{1}{380} + \frac{1}{570}$;

$\frac{2}{97} = \frac{1}{56} + \frac{1}{679} + \frac{1}{776}$; $\frac{2}{99} = \frac{1}{66} + \frac{1}{198}$

general rule was followed in its construction, although such rules could have easily be given. One such rule* is contained in the classic work of Leonardo of Pisa, written in 1202, A. D. Probably the table is a collection of results obtained by many different scholars handed down from generation to generation.

The Egyptians had a special symbol for $\frac{2}{3}$ but all the other fractions employed by them had unity for their numerator.* Even if they desired to employ only fractions with unity as a numerator, this table cannot have been of much real value, for it is easier to represent $\frac{2}{13}$ by $\frac{1}{13}+\frac{1}{13}$ than by $\frac{1}{8}+\frac{1}{52}+\frac{1}{104}$. The table is a good example of the fact that cumbersome methods are frequently employed before the easier methods are discovered. The fact that the Greeks employed such fractions along with the general fractions gives evidence of the difficulty of replacing the useless by the useful in the development of knowledge.

While this table bears definite evidence of the immaturity of the Egyptian intellect it also bears evidence of great strides in intellectual development. The appreciation of such truths, which require some continuity of thought to verify, shows that the Egyptians at this early date were very far in advance of many uncivilized nations at the present time. This fact will become clearer when the other parts of this marvelous work are exhibited.

The second section of the arithmetical part consists of only six closely related examples. They illustrate how the numbers 1, 3, 6, 7, 8, 9, respectively may be divided into ten equal parts. As is the case with most of the examples throughout the book, Ahmes gives only the answers and verifications. For instance, he says $\frac{9}{10}=\frac{2}{3}+\frac{1}{5}+\frac{1}{30}$ because 10 times $\frac{2}{3}+\frac{1}{5}+\frac{1}{30}=9$. In order to multiply these fractions by 10 he always doubles them, then doubles these results and thus obtains their four-fôld. He finally doubles these results and thus obtains their eight-fold. To multiply by 10 he simply adds the double to the eight-fold. That is, he employs the principle that any natural number is the sum of different powers of 2.

There is no evidence that any multiplication table was in use among the Egyptians. On the contrary, the examples that have

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* Cf. Harzer, Jahresberich der Deutschen Mathematiker-Vereinigung, vol. 14 (1905), p. 315.

* In his History of Mathematics, Ball says that the Egyptians used also the fraction ¾ ; 3d edition, p. 4. T iis statement is incorrect.

come down to us indicate that multiplication was accomplished by successive addition. The earliest evidence of a multiplication table is found in the work of Nicomachus who lived about 100 A. D., and wrote the first classic arithmetic. Even this table may have served another purpose.

As in the preceding section so we find in this section evidences of immaturity of thought along side with the display of judgment. An instance of the latter is furnished by the omission of the numbers 2, 4, and 5. Ahmes seems to have realized that $\frac{2}{10}$ and $\frac{2}{10}$ and respectively equal to $\frac{1}{5}$ and $\frac{1}{2}$, and hence the division of 2 and 5 into 10 equal parts need not be considered. Moreover, $\frac{4}{10} = \frac{2}{5}$ and hence it is not necessary to divide 4 into 10 equal parts as $\frac{2}{5}$ has been resolved into unit-fractions in the preceding table. An instance of immaturity is furnished by the fact that 1 is divided into ten equal parts, and the result $\frac{1}{10} = \frac{1}{10}$ is proved by showing that the double of $\frac{1}{10}$ is $\frac{1}{5}$ and the eight-fold of $\frac{1}{10}$ is $\frac{2}{3} + \frac{1}{10} + \frac{1}{30}$ From the fact that $\frac{1}{5} + \frac{2}{3} + \frac{1}{10} + \frac{1}{30} = 1$ it therefore follows that $\frac{1}{10} = \frac{1}{10}$.

The third section of the arithmetical part consists of eighteen examples. Fifteen of these give the fractions obtained by adding to a given fraction its one-half and its one-fourth, or its two-third and one-third. In the latter case the fractions are simply doubled by the operation, but Ahmes goes through the details in each of the six examples where a fraction is increased by its $\frac{2}{3}$ and $\frac{1}{3}$. His methods appear very cumbersome. For instance, when he increases $\frac{1}{4}$ by its $\frac{2}{3}$ and its $\frac{1}{3}$, he observes that $\frac{2}{3}$ of $\frac{1}{4} = \frac{1}{6}$ and $\frac{1}{3}$ of $\frac{1}{4} = \frac{1}{12}$. Instead of adding $\frac{1}{4} + \frac{1}{6} + \frac{1}{12}$ he reduces them to the common denominator 18 and notes that $\frac{1}{4} = \frac{4\frac{1}{2}}{18}$, $\frac{1}{6} = \frac{3}{18}$, and $\frac{1}{12} = \frac{1\frac{1}{2}}{18}$. Hence, the result is $\frac{9}{18} = \frac{1}{2}$.

In the last three examples of this section it is required to find the difference between a given fraction and unity, or between a given fraction and $\frac{2}{3}$. The first one of these reads as follows: "You are told to complete $\frac{2}{3} + \frac{1}{51}$ to 1." This is done by observing that $\frac{2}{3} = \frac{10}{15}$, and hence the required fraction is $\frac{4}{15}$. To reduce this to Egyptian fractions Ahmes determines the number which must be multiplied into 15 to give 4. He first multiplies 15 by $\frac{1}{15}$ and thus obtains 1. He then multiplies by $\frac{1}{10}$ and obtains $1\frac{1}{2}$. Finally he multiplies by $\frac{1}{5}$ and obtains 3. By adding the first and

last result together he obtains the required number 4. Hence $\frac{1}{5}$ + $\frac{1}{15}$ must be added to $\frac{2}{3}$ + $\frac{1}{15}$ to obtain 1.

Section IV. is the most interesting part of the whole book. It is devoted to elementary algebra. Some of the problems are similar to those met in our present text-books on algebra, except that the unknown is called "heap," instead of x. The following examples exhibit the nature of these problems: "Heap, its seventh, its whole, it makes 19." "Heap, its $\frac{2}{3}$, its $\frac{1}{2}$, its $\frac{1}{7}$, its whole, it makes 33." It is a significant fact that the oldest mathematical work extant should include elementary algebra. The equations to which the problems give rise are all of the first degree. The Egyptians could not solve the quadratic equation as they did not even know how to extract the square root.

The fifth and last section of the arithmetical part is devoted to the division into unequal parts. The first examples state that 100 loaves are divided among 10 people. Four of these receive 50 loaves while the remaining six receive also 50 loaves. It is required to find the difference between the amount received by each of the four and each of the six. The second example requires to find five terms of an arithmetical progression such that the sum of the terms is 100 and that $\frac{1}{7}$ of the sum of the first three terms is equal to the sum of the last two terms.

The last problem is solved by assuming that the common difference is $5\frac{1}{2}$ and that the last term is 1. The terms obtained in this way are 23, $17\frac{1}{2}$, 12, $6\frac{1}{2}$, 1. As their sum is 60 instead of 100, Ahmes increases each of these terms by $\frac{2}{3}$ of their value and thus obtains the values of five numbers in arithmetical progression which satisfy the conditions of the problem. This completes the arithmetical part of the work under consideration. As this is by far the most important part of the book we proceed to give a brief summary of its contents.

In addition to the table of unit fractions, it is composed of 40 problems, while the remaining four parts together are composed of 44 problems. The most advanced of these problems relate to linear equations and to arithmetical progression. The main difference between the method of operation pursued by Ahmes and those of the present day is due to the fact that the only fractions which were allowed to appear in the results were $\frac{2}{3}$ and those having unity as a numerator, while the denominator was frequent-

ly more than 1000. This restriction seems to us very unfortunate.
While it is no more arbitrary than some of those under which we
labor at the present day (e. g. the restriction to the rule and the
circle in plane geometry constructions), yet it seems to have been
more detrimental to progress. It had the advantage that fractions
could be multiplied by merely multiplying the denominators.
Hence the multiplication of fractions was just as simple as the
multiplication of integers.

The second and third parts of the Handbook of Ahmes deal
respectively with stereometry and plane geometry. We would
naturally have expected that these two subjects would have been
treated in the reverse order, as the plane figures are involved in
the mensuration of solids. It is possible that the arrangement
was made according to what appeared the relative importance of
the subjects and we are reminded of the fact that spherical trigo-
nometry was developed earlier than the plane trigonometry.

The part on stereometry begins with the following example:
"Directions to calculate a round granary, whose diameter is 9 and
height 10." The problem is solved by reducing the diameter by its
$\frac{1}{9}$ and then squaring the remainder for the area of the circle.
This result is multiplied by $\frac{2}{3}$ of the height to obtain the volume.
Several interesting facts appear in this operation. In the first place,
the Egyptians regarded the circle equal to a square whose side is
$\frac{8}{9}$ of the diameter of the circle. This is equivalent to considering
$\pi = 3.1604$ . . . It is interesting to note in this connection
that the Japanese used to consider $\pi = 3.16$.

The fact that the area of the circular base is multiplied by $\frac{2}{3}$
of the height instead of by the height presents greater difficulties,
which have not been definitely solved. It may be that granaries
had sloping sides and that the given base is the smaller of the two
bases. In the examples in which the base is a square the area
of the base is also multiplied by $\frac{2}{3}$ of the height. All the examples
dealing with the mensuration of solids relate to the determination
of the contents of granaries whose dimensions are given or to the
determination of the dimensions when the contents are given. In
the latter it is assumed that the base is a square whose side is 10
units.

In the part on plane geometry there is one example in which
the area of a circular field is computed. This is again done by

finding the area of a square whose side is $\frac{8}{9}$ of the diameter of
the field. The following example, at first sight, seems to fix a
remarkable low limit to the geometrical attainments of the Egyp-
tians. It is definite proof that Ahmes did not know how to find
the area of an isosceles triangle. The problem is to find the area
of an isosceles triangle whose base is 4 and whose side is 10.
Ahmes simply multiplies half of the base into the side, giving 20
as the area.

In order to find the exact area from the given data it would be
necessary to find the value of $\sqrt{100-4}=\sqrt{96}$. It was noted above
that the Egyptians did not know how to extract the square root
and hence this operation was impossible for them. Moreover, the
error which Ahmes commits is not very great since his result is
only about 2 per cent. too large, an error which in his day may
have passed unnoticed. A similar error is made in the next prob-
lem where it is required to find the area of an isosceles trapezoid.
Ahmes multiplies half the sum of the parallel sides by the other
side, instead of by the altitude.

The part devoted to the calculation of pyramids has presented
great difficulties. It deals with the quotient obtained by dividing
one-half of a certain line in the pyramid by another line. This
quotient is called Seqt, and seems to be the cosine of the angle
between an edge o fthe pyramid and the diagonal of the base
Hence this part is sometimes regarded as a chapter in trigonom-
etry but the data are so meagre as to convey very little definite
information. The first of these examples reads as follows:
"Directions to calculate a pyramid 360 yards at the base, 250 at the
edge, let me know their ratio." It is solved in the following man-
ner: Take $\frac{1}{2}$ of 360, this gives 180; multiply 250 to find 180, this
gives $\frac{1}{2}+\frac{1}{5}+\frac{1}{50}$ of a yard. Sincs a yard is 7 hand-breadths we
have to multipliy 7 by $\frac{1}{2}+\frac{1}{5}+\frac{1}{50}$. Hence the Seqt is $5\frac{1}{25}$
hand breadths.

The last part consists of a collection of twenty-three practical
examples which relate to the division of loaves, wages of a herds-
man, paying laborers, the feed of oxen, etc. From the type of
these examples it is inferred that Ahmes had the wants of the
farmer especially in mind in writing his book. Two of the ex-
amples Nos. 80 and 81, are devoted to the change from one system
of measures to another—a type of problems found in our modern

arithmetics. One of them seems to involve a knowledge of the formula for the sum of a geometrical progression.   .

While the Handbook of Ahmes raises many questions which cannot be definitely answered at the present time it gives conclusive proof of the following facts: As early as 1700 B. C., (and probably much earlier as Ahmes claimed to have modeled his book on an old work) the Egyptians had a fairly advanced knowledge of fractions, the linear equation, the arithmetic series, and probably the geometric series. They employed a formula for the area of the circle which gives a comparatively close approximation. They had made a beginning in the study of similar figures but their formula for the area of a triangle was a crude approximation.

A QUESTION.

I venture to draw your attention to "A Geometrical Fallacy" on p. 369 School Science and Mathematics for May, 1905. It seems to me the writer of the note in question has entirely misunderstood the terms "mutually equilateral" and "mutually equiangular." If, as is clearly intended in the proposition as originally stated, the n-gons are mutually equilateral and mutually equiangular, equal angles lying between equal sides in each, and read in the same order, i. e., right to left or reverse in both, then the proposition is evidently true. Further, the writer assumes two n-gons congruent to begin (line 8) and concludes by asserting that they are not in general congruent. Can you explain?

W. D. Patterson.

THE REPLY.

If, as the writer states, two polygons are mutually equilateral, mutually equiangular, and *the equal angles lie between equal sides in each*, then the polygons are congruent.

The third condition is obviously necessary, but it seems to have always been overlooked, or, at least, as in the comments of Mr. Patterson, it is assumed to be a logical consequence of the first two conditions.

That this is not true is shown in the note referred to; for though it begins with two polygons which are congruent, and which therefore satisfy the three conditions, each is afterwards altered so that the first two are satisfied and the third is not, and they no longer are congruent.

G. W. Greenwood.

Department of Metrology. Notes.

In Australia. The following, under date of May 29, 1905, is from Edward Johnson, Secretary of the Decimal Association:

"Recent advices from Australia show that one of the new bills to be introduced in the coming session of the Commonwealth Parliament is to deal with weights and measures. This bill, on the lines of that recently passed by the New Zealand Parliament under which a proclamation may at any time be issued giving effect to the metric system throughout the colony from the beginning of next year, has been under the consideration of the Minister of Commerce. He has issued instructions that the principle shall be included in the new bill and that a similar provision to that included in New Zealand giving the metric system effect from a date to be proclamed shall be embodied. This will provide not only an interesting but revolutionary departure. The powers to be contained in the measure have not yet exactly been defined. The system is for a time to be permissive, but power is reserved to give it compulsory effect after a day fixed by the Governor General in Council. At one time in the Federal Parliament there was a suggestion that the metric system of weights and measures and decical system of coinage should be introduced concurrently. This has not been found to be practicable." R. P. W.

Legal and Customary Weights Per Bushel of Seeds. In a 10-page pamphlet, under the above caption, the Bureau of Plant Industry, Bulletin No. 51, Part 5, U. S. Department of Agriculture, gives a series of tables, compiled by Edgar Brown, showing the great diversity of weight per bushel of the same and different seeds in the various states. Lyster H. Dewey, Acting Botanist, remarks: "The varying use in weights of our common field and garden seeds in different states must necessarily lead to confusion. It is hoped that a more widely disseminated knowledge of this varied usage, such as is pointed out in this paper, will tend to lesson the confusion and bring about greater uniformity. Furthermore, by calling attention to the present unsatisfactory conditions it may aid in preparing the way for general introduction of the metric system now used in nearly all other civilized countries." R. P. W.

In New Zealand. The Executive Head of the government of New Zealand has given notice—according to *Science*—that the metric system of weights and measures must be exclusively used in that country, beginning next year . It will be recalled that an Act giving the Governor power to issue such a proclamation, to go into effect any time after Jan. 1, 1906, was passed Aug. 29, 1903. By the provisions of this Act any person using or having in his possession illegal weights or measures is liable to a fine not exceeding ten pounds.

In more ways than one is this progressive country giving us valuable object lessons. Her next move will probably be the abolition of English money and the introduction of decimal coinage. R. P. W.

TEMPERANCE PHYSIOLOGY.

It is with great pleasure we note the co-operation of the Woman's Christian Temperance Union of Massachusetts, and the Teachers of that state with a view to uniting the efforts of both in a more rational method of teaching Temperance Physiology in the schools. It was the desire of the Central Association of Science and Mathematics Teachers to co-operate with the temperance people to bring about reforms that would make the work satisfactory to all and profitable to the children; but our efforts were met with the statement that we were "mistaken," that we were ignorant and in league with saloon interests. This "Committee of Twelve," composed of six members of the Woman's Christian Temperance Union of Massachusetts, and six educators, has been at work for five years and the result of their labors is soon to be published. Their preliminary report is so full of interest to members of the Central Association of Science and Mathematics Teachers, that we give the chief part of it below:

A STATEMENT OF FACTS WITH REFERENCE TO THE FORMATION AND WORK OF THE "COMMITTEE OF TWELVE."

Published by order of the Executive Committee of the Massachusetts Woman's Christian Temperance Union.

1. The appointment of the Massachusetts Committee of Twelve was rendered necessary by the unfortunate relationship which, during the winter of 1898 and 1899, had come to exist between the educational and temperance forces of the State. This unfortunate relationship had arisen from the attempt on the part of the temperance forces at more drastic legislation concerning the teaching of physiology and hygiene in our public schools. This proposed legislation was vigorously opposed by the majority of the teachers as being inimical to the best interests of both pupils and temperance. This apparent antagonism was greatly deprecated by many, among both teachers and temperance workers, especially in the ranks of the Woman's Christian Temperance Union.

2. Since it seemed to many that the difficulties had arisen mainly through misunderstanding, it was deemed wise to come together for informal council, which was done several times. At a meeting held in the State House January 6, 1900, resolutions were suggested and a mass meeting called for their ratification in the vestry of the Park Street Church, January 27. At this meeting the suggested resolutions were slightly amended and adopted by an overwhelming majority of the more than 200 persons present. The first resolution read:

"Resolved, That it is both desirable and necessary that all the friends of temperance in the State of Massachusetts should work together in the battle against intemperance," and the last, "That a Committee of Twelve be appointed, six from among the teachers and superintendents of the State, and six from among the members of the Woman's Christian Temperance Union and other State Temperance organizations which have special interest in the enforcement of the present law. To this Committee shall be referred any special difficulties arising on either side."

*   *   *   *   *   *

4. Several minor matters were attended to in the earlier meetings of the Committee. It was voted that representatives from each side should be invited to the conventions of the other, which was largely done during the first year. Then, as the chief "difficulty" seemed to be on the part of the teachers, that there was not a uniform Course of Study which seemed to them adapted to the needs of Massachusetts schools, it was voted to proceed to the preparation of a course which,

it was hoped, would be acceptable to both temperance societies and
teachers throughout the State. Four years and a half have been con-
sumed in an effort to prepare such a course. The reason for such great
delay has lain in the fact that almost from the outset, it became ap-
parent that there was both a majority and minority committee and
that, between the two, there was a great gulf fixed which it seemed im-
possible to bridge. Nine members of the Committee were ready to
make every possible concession which did not violate a principle for
the sake of securing harmony of action, but to three members there were
no minor matters involved and a principle was at stake in even the
slightest differences of opinion. Again and again a practical unanimity
seemed reached only to have it appear at the next meeting, or before
the next meeting, that the majority had misunderstood the minority,
and that the weary attempt at reconciliation must again be resumed.
Thus the delay for which the Committee has recently been publicly re-
proved has been due almost wholly to the three members of the minority
whose names appear affixed to that public reproof.

5. At the last two meetings of the Committee of Twelve, held
at the State House on January 28, and March 11, 1905, it was decided
to proceed at once to the publication of the Course which had occupied
the attention of the Committee for so long a time. It was also voted
that the present work of the Committee should cease with the grammar
grades as conditions did not seem to demand the publication of an out-
line course for the High schools of the State. Through very genuine
and generous concessions of many points which, from a pedagogical
standpoint, were deemed of great importance, such harmony has been
reached as will enable the sending out of a Course of Study with an
outline for teaching in each grade from the 1st to the 9th. This sug-
gested Course is a very strong one with reference to its temperance
teachings, and the points of difference between the report of the Commit-
tee of Twelve and the Minority report, which will doubtless be issued,
must lie alone in the facts that no text-books are recommended for
Fourth-grade pupils, and that "not enough physiology" has been
specified in Grades 7 and 8. It is true that the Committee of
Twelve in its Course of Study has emphasized hygiene rather than
physiology, because it believes the former to be the nearer, more
natural point of contact in the life of the child, but it is also true
that the text-books, which are definitely recommended in every
grade from the 5th to the 9th, will contain abundant physiological
data for the use of both teacher and pupils. Moreover, the course
recommended by the Committee of Twelve carries the thought of
personal hygiene up through the successive stages of "Hygiene in the
Home," "the School," the "City or Town" to "State and Nation."
It is a strong course and, when published, will be on sale at State head-
quarters, where the local Unions may have an opportunity of judging
for themselves. The "International Course of Study," to which refer-
ence will be made in the next paragraph, is also a strong, valuable
Course of Study, and may be secured from Mrs. Mary H. Hunt, 23
Trull Street, Boston. It must be remembered that the function of the
Committee of Twelve in this and all other matters is purely advisory.
It is as possible to-day as it ever was for the women of the local
Unions to recommend any outline course they may choose to their re-
spective School Boards. The School Boards alone are competent to
decide as to the adoption of a course in this or any other branch.

* * * * * *

The Executive Committee of the Massachusetts Woman's Christian
Temperance Union hereby expresses unqualified approval of the efforts
of the Committe of Twelve to formulate a Course of Study in temperance
physiology, which will harmonize the educational and temperance

forces, and we hereby endorse the action of our State President in her representative capacity.

We also reaffirm the resolution passed at Leominster, paragraph 2, "We hail the great body of teachers in our State as our allies and co-workers in the moral and scientific education of our children and youth, and pledge ourselves to be more diligent in the future in seeking opportunities and devising methods of assisting them in their great work."

* * * * * *

7. We are convinced that the effort of the Committee of Twelve was a righteous effort; that its work has tended towards strengthening rather than weakening the temperance teaching in our schools; that a better relationship exists to-day between the temperance and educational forces than would exist but for its work. We are sure that the great gulf which, at one time, separated the two bodies, has narrowed down to a mere ribbon of difference which will soon be wholly forgotten in the earnest, concerted action of each for the training of the children and youth of our State in temperance and righteousness. We regret that we cannot all see alike, but we bespeak charity of judgment in all points of difference and united, strong action in all points of unity. We earnestly urge upon our constituency everywhere the thoughtful, careful, prayerful consideration of this, the only statement sent out by the Massachusetts Executive Committee and we venture, in particular, to express the hope that no further documents, reflecting upon the Committee of Twelve, or upon the temperance situation in Massachusetts, may be sent throughout the State. Such methods are always reactionary and tend to disintegrate rather than to build up. May we not, rather, "with malice towards none with charity for all," stand together upon our points of harmony and, with united voice and united effort, cry, "The Old Bay State shall be redeemed!"

Respectfully submitted,
KATHARINE LENT STEVENSON,
HARRIET E. SAWYER,
REBECCA F. B. ROUNDS,
Committee.

A fellow-teacher wishes to know the names of the text-books criticised by the "Committee of Fifty." A full list of them may be found on page 29, Vol. I, "Physiological Aspects of the Liquor Problem." Tracy's Physiology is one of them, but Coulton's is not. As to specific errors, we refer the readers to the above-named work of the "Committee of Fifty," as well as to the books themselves.

JAMES E. ARMSTRONG, Chairman.

LITERARY NOTES.

An interesting illustration of practical social welfare work is seen in the action of a telephone company in one of our largest cities in adopting Dr. Emma E. Walkers' successful book, "Beauty Through Hygiene," recently published by A. S. Barnes & Co., for distribution among the girls employed at the central stations.

Sir William Ramsay has approved so highly of Professor R. K. Duncan's remarkable summary of recent scientific discovery, "The New Knowledge," just published by A. S. Barnes & Co., that he has written a commendation of the book for "Nature," and has also written the publishers to express his appreciation.

SYLLABUS OF COURSE IN CHEMISTRY FOR THE EVENING HIGH SCHOOLS OF THE CITY OF NEW YORK.

FIRST YEAR.—Elementary Chemistry, one hour sessions, five evenings per week throughout the year, or, two hours per evening one half the year.

SECOND YEAR.—Qualitative analysis, or, Organic Chemistry as in third year.

THIRD YEAR.—Quantitative analysis, or, Organic Chemistry.

THE FIRST YEAR CHEMISTRY.

The work of the first year should be distributed between class and laboratory in the proportion of three evenings of class to two of laboratory work. The class work should be composed of both quiz and demonstration. Some standard text-book should be made the basis of all the work of the year.

DEMONSTRATION WORK.—The demonstration work performed by the teacher in the presence of the class should cover and precede all experiments performed by the student in the laboratory, and should be accompanied by all explanations and conclusions involved in the same. In addition to this, experiments of value not mentioned in the laboratory work, as outlined in this syllabus, should also be performed in the demonstration. Among these are the following:

1. Quantitative synthesis of water.
2. Use of the oxy-hydrogen blowpipe. (Optional.)
3. Decomposition of water by chlorine.
4. Making of hydrogen peroxide with test for the same.
5. Reduction of nitric acid to ammonia.
6. Oxidation of ammonia to nitric acid. (Optional.)
7. Spontaneous combustion of phosphorus and iodine.
8. Decomposition of water by iron. (Optional.)
9. Combustion of ammonia.
10. Fermentation.
11. Making of phosphene.
12. Making of arsine.
13. Marsh's test, using both arsenic and antimony in comparison.
14. Making of ammonium ammalgam.
15. Making of test for gold.
16. Making of "lead tree."
17. Electrolysis of solutions of metallic salts.

QUIZ.—The quiz should constitute at least a part of each evening's work, and should include written tests from time to time.

LABORATORY WORK.—The time allowed to the various subjects in laboratory work should be approximately that indicated below. A laboratory note-book containing carefully prepared original notes on each experiment should be kept by each student. The laboratory exercises should be forty-six in number, and should include the following subjects:

1. Illustrations of Chemical Action.
2. Causes of Chemical Action.
3. Compounds and Mixtures.
4. Manipulation and Glass-working.
5 & 6. Oxygen; its preparation by two methods and a study of its properties.
7 & 8. Hydrogen; its preparation by two methods and a study of its properties.
9. Water and Ozone.
10. Composition of Air—Quantitative determination of Oxygen content.
11. Ammonia; its preparation and properties.
12. Nitrous oxide.
13. Nitrogen dioxide and tetroxide.
14. Nitric acid.
15. Neutralization and salt-forming
16. Charcoal filter, lampblack and reduction of CuO by carbon.
17. Destructive distillation of wood.
18. Carbon monoxide and dioxide.
19. Carbonates and hard water.
20. Methane.
21. Acetylene.
22. Hydrofluoric acid and etching.
23. Chlorine; its preparation and properties.
24. Hydrochloric acid; its preparation and properties.
25. Bromine; its preparation and properties.
26. Iodine; its preparation and properties.
27. Action of H_2SO_4 on Bromides and Iodides—A comparison with its action on chlorides.
28. Making various forms of sulphur.
29. Sulphides—hydrogen sulphide; its action on metallic salts.
30. Sulphur dioxide; its preparation and properties. Study of its solution in water. Sulphites and their decomposition by acids.
31. Oxidation of SO_2 to SO_3 and solution of SO_3 in water. Test for sulphates.
32. Action of H_2SO_4 on organic matter. The heat of dilution of H_2SO_4.
33. Hydrogen equivalent of zinc or magnesium. (Optional.)
34. Burning phosphorus in confined air over water and testing the solution for H_3PO_4. Spontaneous combustion of phosphorus from a solution of CS_2.
35. Boron-making and crystallizing H_3BO_3. Making flame and tumeric tests for H_3BO_3. Making borax beads with cobalt, etc.
36. Silicon-silicic acid and SiO_2 from Sodium Silicate. Solubility of SiO_2 in Alkalies. Hydrofluosilicic acid test for silicon.
(One evening for each of the above exercises.)
37—46. The remaining ten evenings of the term should be devoted

to a study of those reactions of the metals most important in qualitative analysis.

THE WORK OF THE SECOND YEAR IN CHEMISTRY.

Students of the second year should take up the regular qualitative analysis of the metals, doing the characteristic reactions of each metal, then choosing which reactions may be used to separate the metals into groups and to separate and identify the metals of each group. The work should follow some well arranged scheme of analysis as, "A Short Course in Qualitative Analysis for Engineering Students," by J. S. Wells. After sufficient work with known mixtures has been done to make the student familiar with the methods, unknown mixtures in solution should be analyzed. The methods and manipulation necessary for the detection of the acid radicals should next be taken up. This should be followed by a systematic analysis, including the usual preliminary and blowpipe analysis, of two or more unknown mixtures or minerals. The analysis of substances containing phosphates should then follow.

In place of the course in analysis as described above, students may elect a course in organic chemistry as described in the third year.

THE THIRD YEAR IN CHEMISTRY.

The work of the third year should, within reasonable limits, be elective: Quantitative analysis should be the basis of the work, either in the form of a general course in that subject or else a course in which the analysis has for its object some particular subject of study or investigation; or, The course be one in Organic Chemistry. In this case the following preparations should be made: Methane, Chloroform, Iodoform, Ethyl bromide, Alcohol, Oxalic Acid, Oxamide, Urea, Nitrobenene, Aniline, Hydraquinone, etc. The making of these preparations should be accompanied by a careful study of some text on organic chemistry such as, "Remsen's Introduction to the Study of the Compounds of Carbon."

Chemistry Notes.

THE USE OF CALCIUM IN LECTURE-TABLE EXPERIMENTS.

Professor A. Senier and Miss R. Clarke contribute to the *Chemical News* of February 24th a short article on the use of calcium in lecture-table experiments. Science is indebted, they say, to a recent development of German industry for a source of calcium from which this metal may now be obtained in quantities of a pound or more, and at a comparatively trifling cost. It is produced by electrolysis in the form of rough cylindrical sticks weighing about a pound each. In color it is white, like aluminium, and it has about the same degree of hardness as ordinary brass. It is easily turned in a lathe, and the turnings, which may be allowed to fall into light petroleum, are a convenient form in

which to employ it. The commercial metal contains 98 per cent of calcium.

Preparation of Hydrogen from Water.—When wrapped in iron gauze and introduced into a pneumatic trough containing water, in the usual way, hydrogen is evolved quietly, and may be collected readily in any desired quantity. At the same time, the water of the trough becomes turbid owing to floating particles of calcium hydroxide. The reaction is so much more moderate and more easily controlled than that with sodium and water, that it is suggested that in schools it be substituted for the latter. Moreover, it is an additional advantage that both products of the reaction, the gas and the solid hydroxide, are observed at once.

Synthesis of Calcium Compounds: Oxide, Chloride, Sulphide, Phosphide.—Calcium turnings are placed in the bulb of a hard-glass tube, with a central bulb, in the case of the oxide and chloride experiments. In those of the sulphide and phosphide, tubes with two bulbs are employed, and the second bulb is charged with sulphur and phosphorus respectively, and the end next to it closed with a cork. In every case the metal is first heated to low redness, and then the dried gas is led over it, or the solid is distilled over it. The oxide, sulphide, and chloride form at once with brilliant incandescence, but the phosphide is obtained only in small proportions. The light emitted in the oxide and sulphide synthesis affects a photographic plate to about the same extent as the burning of the same quantity of magnesium.

Other Applications.—Calcium, burning in air, and then plunged into carbon dioxide, like magnesium, removes the oxygen and liberates carbon. Calcium heated to redness, appears to have no action on dried ammonia gas.—*School World.*

E. H. Sargent & Co., Chicago, will import this Calcium for any one.

Pursuing his studies on the presence of methyl aldehyde in smoke, in the course of which he has established the fact that it is found in all usual combustions, M. Trillatt has comunicated to the Academie des Sciences these conclusions: Formic aldehyde exists in the soot of our chimneys and in the air of cities. It is found in noticeable quantities in the combustion of sugar, juniper berries, sweet roots, benzoin; in particular, when the combustion occurs in contact with hot metallic surfaces, whose catalytic effect intervenes to increase the yield. The constant presence of formic aldehyde in the gaseous or solid part of fumes explains their disinfecting action, in which the good effects of formic aldehyde were utilized long before they were known or studied. —*Scientific American.*

The results of the geological surveys that were carried out by Mr. H. H. Hayden, of the Geological Survey of India, who was attached to the recent British expedition to Lhasa, have been published. From his investigations the country is strikingly poor in minerals of economic value, the only one found *in situ* being gold, which is obtainable in very small quantities from the coarse gravel beds of the Tsangpo. The largest yield obtained by panning was only at the rate of 28 grains of gold per ton of gravel. Concentrates were found to contain, in addition to much magnetite and zircon, a small quantity of rutile and hercynite, and probably uraninite. During his sojourn at Lhasa the geologist purchased varied samples of the gem stones employed by the local jewelers, among them being turquoise, ruby, tourmaline, emerald, and sapphire. The jewelers stated that all these stones were brought from a considerable distance, some coming from Ladak and Mongolia, and others from India. Mr. Hayden could obtain no trustworthy information as to the existence of any native sources of gems, and concludes that turquoise is practically the only native gem stone. He also succeeded in disproving the general belief that coal is to be found at Lhasa.—*Scientific American.*

A NEW INCANDESCENT LAMP.

A new incandescent lamp with a zirconium filament is announced in Germany. Professor Wedding, the well-known physicist, recently presented a lamp of this kind to the Electro-technical Society of Cologne. The details of the process are as follows: To obtain the filament he submits oxides of zirconium and magnesium at a high temperature to the action of hydrogen, which gives an alloy of a more or less constant composition. This body is then pulverized, and by adding a cellulose solution it is transformed into a plastic and homogeneous mass. It is from this mass that the filaments are drawn. The latter are carbonized in an atmosphere which is free from all traces of oxygen, and then present a metallic appearance. It is said that one pound of zirconium will furnish 50,000 filaments. The new lamp is to be placed on the market at the price of $0.37. Under regular working, the zirconium filament consumes a current of 2 watts per candle-power, which is less than for the usual carbon filament. The zirconium lamps are made at present to run with a current of 37 volts, and three of them can be conveniently placed in series across the usual 110-volt circuit. Another type uses 44 volts, and five lamps are connected upon a 220-volt circuit. To obtain a high candle-power lamp they place several filaments in the same bulb and the lamp is then connected directly upon a 110-volt circuit. Experiments which have been made with the lamp shows that it has a life of 700 to 1,000 hours.—*Scientific American.*

Biology Notes.

Bulletin No. 59 of the United States Bureau of Forestry entitled, "The Maple Sugar Industry," contains much valuable information. The topics treated are "History of the Industry," beginning with sugar-making by the American Indians and ending with the most modern processes; "The Present Status of the Industry;" "Sugar Maples," in which six pieces of sugar producing trees are discussed; "Sugar Groves," discussing the forestry aspects of sugar trees; "Maple Sap," "The Manufacture of Sugar and Syrup," and the "Adulterations of Maple Products." At least seven-eighths of the article offered in the market as maple syrup is spurious. The different methods of adulteration are described. Excellent illustrations are a valuable feature of the bulletin.

Those interested in the subject of "Forestry" will welcome the U. S. Forest Bulletin No. 61 on "Terms Used in Forestry and Logging." If carefully read and followed this bulletin will do much to clear up many misunderstandings that come about through à misuse of terms relating to forestry.

Economic scientists who are conversant with agricultural conditions in Cuba and similar regions will appreciate the importance of a recent publication by Dr. Mel T. Cook and Mr. M. T. Horne of the Cuban Agricultural Experiment Station on "Insects and Diseases of Tobacco." In addition to making a resume of known insect treatments, the authors report successful attempts at using bisulphide of carbon and hydrocyanic acid gas on Cuban insects that have been extremely injurious. Stored tobacco, both crude and that ready for the retail market, were treated in such a way as to show that the insects may be killed without any accompanying injuries to the tobacco. A second part of the paper treats briefly a number of tobacco diseases not caused by insects.

NOTE ON MOUNTING OF LARGE SPECIMENS.

The mounting and spreading of specimens preserved in liquids.

The usual method of attaching specimens to strips of glass is long and laborious. The difficulty of cutting the glass so as to exactly fit the container and the time and care required to drill holes or file notches in the glass for threads that are to hold the object, are serious objections.

By using thin sheets of wax, such as paraffine, of any desired color, the process is greatly shortened.

The fitting is easier and quickly done. Threads for holding the object, or in some cases the feet, may be slightly embedded in the wax with a hot needle, or small pins may be used.

A spider so mounted is satisfactory after some months.

L. B. GARY,
Central High School, Buffalo, N. Y.

Problem Department.

Professor Ira M. DeLong,
Boulder, Colo., Editor.

Professor Ira M. DeLong, Boulder, Colo., with the assistance of Professor Saul Epsteen, also of Boulder, has kindly consented to take charge of our problem department. Readers interested in this department, which will be devoted to the high school field, are requested to forward problems, solutions, and other communications pertaining to the work of this department, directly to Professor DeLong, or to Professor Epsteen.   Mathematical Editor.

Readers of the magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the authors. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

1. *Proposed by the Editor.*

Find x, y, z, given $xy = 3 (x + y)$, $xz = 8 (x + z)$, $7 yz = 9 (y + z)$.

2. *Proposed by the Editor.*

A man and a boy agree to dig a patch of potatoes for ten dollars. The man can dig as fast as the boy can pull tops, and he can pull tops twice as fast as the boy can dig. How should the money be divided?

3. *Proposed by the Editor.*

A garrison of 500 men was victualled for 48 days; after 15 days it was reinforced, and then the provisions were exhausted in 11 days; required the number of men in the reinforcement.

GEOMETRY.

1. *Proposed by the Editor.*

In any triangle ABC, if BP and CQ be drawn perpendicular to AB, then $BC^2 = AB$. BQ + AC. CP. There should be: $AB \times BQ + AC \times CP$.

BC''

2. *Proposed by the Editor.*

DF is a straight line touching a circle and terminated by the parallel tangents AD and BF. Show that the angle subtended by DF at the center is a right angle.

3. *Proposed by the Editor.*

In a given triangle, inscribe another triangle whose sides shall pass through given points.

TRIGONOMETRY.

1. *Proposed by the Editor.*

If $A + B + C = 90°$, prove that tan A tan B + tan A tan C + tan B tan C = 1.

2. Prove that the triangle ABC is isosceles, if $2 \cos B = \dfrac{\sin A}{\sin C}$

Report of Meetings.

NATURAL SCIENCE ASSOCIATION OF ONTARIO.

The annual meeting of the science teachers of Ontario took place in connection with the Ontario Educational Association in Toronto, on April 25 and 26. The attendance, interest and profit of the meetings were fully up to the mark of former years. We were glad to note a number of new faces.

Mr. Charles M. Turton, business manager of SCHOOL SCIENCE AND MATHEMATICS, Chicago, was a welcome visitor. A goodly number of members handed in their names as subscribers and we look forward to having SCHOOL SCIENCE as our organ in the near future. A number of members expressed themselves as having received very valuable suggestions from its pages.

Mr. A. J. Madill, B. A., of Orillia, acted as press reporter in an able manner. The press accounts were necessarily brief, but some of the papers will appear in the proceedings issued this summer.

The president, Mr. T. H. Lennox, B. A., of Stratford, gave a very thoughtful address dealing with various aspects of science work, especially advances in the teaching of chemistry. W. Lash Miller, Ph. D., F. B., Kenrick, Ph. D., and F. B. Allan, Ph. D., of the chemical staff of the University of Toronto, discussed the new requirements in chemistry prescribed for matriculation and teachers' examinations. The proposal to abolish the atomic theory as an essential part of the teaching of chemistry called forth a lively discussion in which the varied notions of the members were brought out. Dr. Miller exhibited some simple appartus, among other things a very simple home-made balance which gave excellent results in a demonstration of the gravity of air, increase of weight in combustion of iron, etc. He criticised the early use of the atomic theory as mischievous on acount of the tendency to lead the student to think that he knows when he really is substituting one expression for another. Dr. Kenrick dealt with some of the errors commonly made by students from high schools and collegiate institutes when beginning their science courses in the university. He noted in most of them a marked tendency to exhibit a bad habit of recording results that were to be expected or such as would be likely to please the instructor. For example, 40 per cent would record that no residue was obtained when a given sample of distilled water was evaporated, whereas distilled water usually left a distinct residue. He contended that any properly observed result is necessarily the right one. He would insist upon pupils writing notes at the moment of observation because scientific accuracy is of more importance than inaccurate neatness. Dr. Allen gave explanation of the meaning of equations and answered numerous questions.

A paper on transferring of gases, written by J. A. Griffin, B. A., who was unavoidably absent, was read by the president and ordered to be

printed. A portion of the paper has already appeared in SCHOOL SCIENCE AND MATHEMATICS.

The following officers were elected for the year 1905-6:

Honorary President, J. B. Turner, B. A., Hamilton, Ontario.

President, R. Lees, M. A., St. Thomas, Ontario.

Vice-President, J. P. Hume, B. A., Campbellford, Ontario.

Secretary-Treasurer, E. L. Hill, B. A., Gulph, Ontario.

Dr. T. L. Walker, honorary president, gave a short address dealing with the method of teaching mineralogy. He advised the making of a set to illustrate the properties of minerals, and the collecting of a set containing all the minerals prescribed in the elementary course. Knowledge of common minerals on sight is much more important than blow-pipe work. In order to give teachers in various parts of the province an opportunity of completing more varied assortments, he suggested that a place be made on next year's program for an exchange of specimens of fossils and minerals.

Before a joint meeting of the Science and Mathematical Sections Prof. Cohoe, of McMaster University, outlined in an interesting manner recent advances in chemistry, especially those that might be considered to belong to physical chemistry.

Prof. W. J. Loudon exhibited an ingenious device of his own construc-tion for teaching polygon of forces, parallel forces, theory of reactions and the like.

The meetings of the general association addressed by Dr. Moulton, of Chicago University, were thronged by members and their friends anxious to hear his scholarly treatment of the topics chosen. All were delighted with his addresses.

The fifteenth annual meeting of the Mathematical and Physical Section of the Ontario Educational Association was held in the Physics room of the University of Toronto, on April 25 and 26.

The opening address by the President, W. J. Robertson, of St. Catherines Collegiate Institute, dealt with the probable effect of the new regulations issued by the Ontario Education Department in 1904, on mathematical teaching in the high schools and collegiate institutes. He advocated examination papers of a more practical character in arithmetic and the requirements of a higher percentage for passing.

G. W. Keith, Gravenhurst high school, read an interesting paper on "The Early Growth of the Teaching of Mathematics in America." He thought that the commercial instincts of the Anglo-Saxon peoples caused them to seek "easy" methods of working problems, giving rise especially in the early times to an excess of memory work and rule learning and a suppression of reasoning and analysis.

A paper on "Some Modern Conceptions in Geometry" was given by W. J. Patterson, Perth Collegiate Institute.

The three great principles of modern geometry, continuity, identity and

duality, were dealt with, the paper concluding with an outline course in modern geometry for secondary schools.

The subject of "Graphical Algebra" was introduced by R. A. Gray, Jarvis Street Collegiate Institute, Toronto. After speaking of the importance of the graph in scientific and industrial work, he outlined a program of work along this line, for the lower, middle and upper forms of our high schools.

I. J. Birchard, of the Jameson Avenue Collegiate Institute, Toronto, gave an address on "The Theory of Positive and Negative Quantities." He objected to the definition found in some text-books. "Numbers less than zero are negative numbers," and explained his method of introducing the subject of negative quantities to beginners.

It was decided to establish a library in connection with the Section, to consist of (a) text-books and treatises on mathematical and physical subjects dealt with in the secondary schools; (b) works bearing on the history and pedagogy of mathematics and physics; (c) periodicals devoted to elementary mathematics and physics. The headquarters of the library will be in the University of Toronto buildings.

The session on Wednesday afternoon was a joint meeting with the Natural Science Section.

Prof. McLennan, of Toronto University, exhibited and explained the action of a radium clock.

Prof. Cohoe, of McMaster University, gave an address on "Some Recent Advances in Chemistry."

The meeting was brought to a close by the exhibtion of some ingenious apparatus for teaching elementary mechanics by Prof. Loudon, of Toronto University.

CHICAGO CENTER, C. A. S. & M. T.

A meeting of the Chicago Local Center was held Saturday, April 1, in the Chemical Laboratory of the Northwestern University Medical School, Twenty-fifth and Dearborn streets, Chicago.

The program consisted of a lecture by Prof. J. H. Long upon "The Conductivity of Liquids." Professor Long, who was a student of Kohlraush when the latter was making his celebrated experiments in liquid conductivity, gave a brief historical review of the work in the subject, illustrated by apparatus that is employed in making determinations.

Among the practical applications of determinations of liquid conductivities are:

(1) The determination of salt content of physiological fluids; e. g., blood urine.

(2) Purity of distilled water.

(3) Comparison of wines of same type or locality.

(4) To determine the amount of salts and total solids in river or lake waters with approximate accuracy (4-5%)

(5) The content of soluble salts in soils.

(6) The moisture content of soils, the moisture content being proportional to the conductivity.   W. E. Tower.

MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The forty-second meeting of the Eastern Association of Physics Teachers was held Saturday, May 20, 1905, in the rooms of the United States Weather Bureau, Boston, and the University Museum, Cambridge.

The morning session was spent in listening to District Forecaster, J. W. Smith, explain the meteorological instruments in use at the stations. He also explained the making of a weather map.

Among the instruments described was the Triple Register. This register records wind directions, wind velocity and minutes of sunshine. There are pens connected electrically with the vane, the sunshine gauge and the anemometer on the roof of the building. Four of these pens correspond to the four points of the compass and record on a chart the direction of the wind every minute. One of the other pens records the velocity of the wind in miles, and the last records on the chart the minutes of sunshine. When the sun is not shining the pen traces a straight, continuous line on the chart, otherwise the line is irregular.

The highest barometric pressure recorded in Boston is 31.08 inches and the lowest 28.63 inches.

After luncheon at the Colonial Club, Cambridge, the Association met in the Meteorological Laboratory, University Museum, Cambridge.

President Palmer called the meeting to order. The secretary presented his report. The committee on magazine literature also made a report.

ORGANIZATION OF A NATIONAL SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

A conference was held at Asbury Park on July 5, 1905, for the purpose of discussing the advisability of organizing a national society of teachers of mathematics and natural science. The conference was attended by thirty-seven teachers, representing nearly all the larger associations of teachers of mathematics and natural science in the United States. Many letters received from teachers who were unable to be present, expressed sympathy with the proposed movement.

Professor Thomas S. Fiske of Columbia University was elected chairman of the conference, and Dr. Arthur Schultze of the High School of Commerce of New York was elected secretary.

There was absolute agreement in regard to the advisability of forming closer permanent relations among the associations represented, and a large majority of delegates were in favor of effecting this by means of a national association. Considerable discussion, however, arose as to whether the new society should be one of mathematical teachers only, or one including also teachers of science. The western associations, for

the most part including teachers of science as well as teachers of mathematics, strongly advocated a mixed organization, while the teachers from the Eastern States seemed, to a considerable extent, to favor a purely mathematical society. The views urged by the Western delegates prevailed, and, on motion of Professor E. R. Hedrick of the University of Missouri, a resolution was adopted to the effect that a national society of teachers of mathematics and science be organized.

The details of the organization were referred to the following executive committee:

Professor Thomas S. Fiske, (chairman), New York, N. Y.
Professor Clarence E. Comstock, Peoria, Ill.
Professor E. R. Hedrick, Columbia, Mo.
Mr. Franklin T. Jones, Cleveland, Ohio.
Professor William H. Metzler, Syracuse, N. Y.
Mr. Edgar H. Nichols, Cambridge, Mass.

Up to the next meeting this committee is to act as council of the society, and a report of its proceedings is to be published in *School Science and Mathematics*.

In the following list of associations represented at the conference the names of regularly appointed delegates are distinguished by the letter (D).

New England Mathematics Teachers' Association.

Chas. E. Bouton, Harvard University, (D) ; Paul Capron, (D) ; Mr. Nichols, Brown and Nichols School, Cambridge, (D).

Association of Teachers of Mathematics in the Middle States and Maryland.

John C. Bechtel, Fletcher Durell, Lawrenceville, N. J.; A. Newton Ebaugh, Miss Susan C. Lodge, Donald C. McLaren, Wm. H. Metzler, Syracuse University, (D) ; J. T. Rorer, Central High School, Philadelphia, (D) ; Arthur Schultze, High School of Commerce, N. Y., (D) ; H. C. Whitaker.

Central Association of Science and Mathematics Teachers.

Otis W. Caldwell, Jos. V. Collins, (D) ; C. E. Comstock, (D) ; G. W. Greenwood, Charles H. Smith (D ; Charles M. Turton, J. W. Young, Charles W. Wright.

Missouri Society of Teachers of Mathematics.

F. T. Appleby, J. S. Bryan, Central High School, St. Louis, (D) ; H. Clay Harvey, (D) ; E. R. Hedrick, (D) ; B. F. Johnston, John R. Kirk, J. W. Whiteve.

Chicago and Cook County High School Teachers' Association.

Edward E. Hill, (D) ; Fred R. Nichols, (D) ; Chas. M. Turton, (D).

Mathematical Section of Michigan School-Master's Club.

Miss Emma C. Ackermann, (D).

New York State Science Association, Mathematical Department.

Glenn M. Lee.

North Eastern Ohio Center, C. A. S. and M. T.
Lamar T. Beman, Cleveland High School, (D); Charles A. Marple, (D).
Ohio Association of Teachers of Mathematics and Science.
Franklin T. Jones, (D); Wm. McLair, (D).
St. Louis Association of Science and Mathematics Teachers.
Wm. Schuyler, McKinley High School, St. Louis, (D).

ARTHUR SCHULTZE, Secretary.

Central Association

FIFTH ANNUAL MEETING CENTRAL ASSOCIATION OF
SCIENCE AND MATHEMATICS TEACHERS.

Attention is called to the fifth annual meeting of the *Central Association* of *Science* and *Mathematics Teachers,* to be held in Chicago on November 24 and 25. This is an association of teachers of science and mathematics in high schools, normal schools, colleges and universities, who are organized for the purpose of keeping abreast with the development of the subjects taught, of advancing the real interests of science and mathematics teaching and those of the individuals who teach. Its membership includes teachers from twelve states. During the present year a number of large mathematical and scientific organizations have become affiliated with this organization with the idea of making this a National Central Association. Though each separate organization maintains its own individuality, all work together for the advancement of common interests, the Central Association being the medium through which co-operation is secured.

The full program of the next meeting will be published in the November issue of School Science and Mathematics early in November. On the general or departmental programs will be Professor T. C. Chamberlain, Dr. J. Pane Goode, Professor Robert J. Aley, Louis Kahlenburg, T. E. McKinney, H. N. Chute, a member of the U. S. Bureau of Forestry, and many others. A number of excursions to places of interest to members of the different sections are being arranged.

It is desired that every person interested in the purposes of this organization should become a member. The membership fee is $2.00 per year and is payable to Mr. E. Marsh Williams, La Grange, Ill. Memberships entitles one to attend all meetings, to receive all reports published by the association, to receive the magazine School Science and Mathematics, which is the official organ of the association, and to the numerous other benefits that come from being associated with those who are working in scientific and mathematical lines of work.

OTIS W. CALDWELL,
President, State Normal School, Charleston, Ill.
C. M. TURTON,
Secretary, 440 Kenwood Terrace, Chicago.

Book Reviews.

*The Place of Industries in Elementary Education. By Katharine E.
    Dopp. 278 pp. 12mo, cloth, net $1.00; postpaid, $1.11. The University of Chicago Press, Chicago, Illinois.*

One of the most promising movements in modern primary education
is that which aims to enlarge the place of the industries in the grammar
schools. In a third edition of *The Place of Industries in Elementary
Education*, by Katharine Elizabeth Dopp, just published, the point of
departure and the treatment of the subject are quite different from
those which usually characterize educational books. The author has
seized upon the instincts and racial characteristics of the Aryan peoples, and with these as a basis she has built up a progressive curriculum
in which the industries occupy a place corresponding to that which
anthropologists have given them in the development of the race. Many
interesting points are brought out in connection with the introduction
of industries in the grades, and the foundation is laid for many new
theories of the application of manual training to the more advanced
grades.

JAPANESE FAIRY TALES.

Teresa Peirce Williston. 50 cents.
Rand McNally & Co., Chicago.
16x20 cms., 88 pages.

The Japanese Fairy Tales, first series, as told by Teresa Peirce Williston, is a fine collection of Japan's choicest stories, interesting in style,
simple and pure in its diction and as well adapted to the home kindergarten as to the primary grades.   A real boon to the story-telling mother,
who is interested in and particular about her child's first readings, being desirous of broadening the scope and vision of the young mind, while
its illustrations by the Japanese artist, Mr. Ogarva, intensifies and enhances the work, acquainting the young reader with the customs, costumes, and modes of living of these quaint little people across the sea.

With its aid to Japanese pronunciations, its suggestions toward developing the artistic side of child nature by illustrating each story in
drawings, and its supplementary reading list for Teachers and Readers,
it becomes a valuable accession to a school course and to a child's library.

BLACK BEAUTY (NEW EDITION.)

12x18 cms., 319 pages.
Edited by Charles W. French.
Rand McNally & Co., Chicago. 40 cents.

Anna Sewell's well-known work "Black Beauty," which has done
so much to ameliorate the treatment of that noble animal, the horse, has
received a new impetus in the fully illustrated edition lately arranged by

Charles W. French, principal of Hyde Park High School, which places this work where every child can intelligently read and appreciate it. Its numbered lines and full notes on each chapter, giving the derivation of words, explanation of terms, references, and quotations, and its bits of incidents from the life and biography of the author, render it not only interesting but extremely valuable as a classic and book of reference. Its suggestive questions, and its intimated subjects for composition and discussion in class work bespeak for it a prominent place in the English courses of our "Grade Schools."

This edition should be placed in the hands of every boy and girl of our land.

WEBSTER'S NEW STANDARD DICTIONARY.

High School and Collegiate Edition.
784 pages. $1.50.
Laird & Lee, Chicago.

This new dictionary for schools contains many features heretofore found only in larger works. The placing of so much valuable material in a handy volume for students' use is accomplished by means of clear, concise definitions and by utilizing every available space, even the fly leaves.

The book is up to date in its definitions of scientific terms. Such terms as radium and Becquerel rays are defined. Series and compound windings of dynamos and the controller of an electric car are examples of the many technical terms illustrated.

Diacritical markings are simplified, each mark used indicating one and only one sound, and a given sound being represented, in the respelling for pronounciation, always by the same mark and letter.

One of the most valuable features is the department of scientific word building in which are given the meanings of all the prefixes and suffixes derived from Latin and Greek, together with the meanings of about two hundred stems. Other departments of value are devoted to geographical names; musical terms; legal terms; medical words and symbols; foreign phrases, classical and modern; mythology; current abbreviations; the metric system; pronounciation of biblical, classical, historical and mythological names.

The body of the work is a valuable book of synonyms. The full page colored plates are worked out with especial care and the wealth of illustration is surprising.

The book is one of a series of four dictionaries adapted to the different grades of school work and to the library. The series is already meeting with the favorable reception which it deserves.   E. E. Burns.

STUDIES IN ANCIENT FURNITURE.

By Caroline L. Ransom. Fellow in the History of Art in the University of Chicago.

24x28 cms., 128 pages, 39 plates, $4.50.

The University of Chicago Press.

When one considers the difficulties which must have been overcome in order to secure the data for this most instructive work he can appreciate the value attached to it by archæologists and students interested in furniture of the ancients.

For the first time the subject of beds and couches of the classical period has been treated exhaustively. Archæologists will appreciate the large amount of hitherto unpublished material which is admirably reproduced in the plates and is discussed at length in a supplement to the main text. Collectors of antique furniture will be interested in the points of contact which are indicated between the styles under consideration here and those of modern times. The accounts of ancient furniture in the current histories of furniture are meager and often erroneous because their authors, who have not themselves the time and training for prolonged studies in the classical field, find little to draw upon; the present book will therefore fill a want for definite, readable, reliable information in regard to ancient furniture. The designer and arts and crafts worker will be interested in the drawings given for the construction of a bed of Greek type and for one of Roman type, as well as in the numerous other illustrations. Marginal rubrics, page headings and adequate indices increase the value of the book as a work of reference.

REVIEW.

A Portfolio of Eminent Mathematicians, edited by David Eugene Smith, Open Court Publishing Co., Chicago, 1905.

For years publishers have vied with each other in the production of pictures of noted personages in the world of literature, art, and science, for use in instructing youth in these subjects. It seems strange indeed, that until now it has been well-nigh impossible for American mathematical teachers to reinforce, vitalize, and humanize their work of instruction through the agency of the portraits of those eminent men about whom the youth of high school mathematical classes hear so much and after all know so little. No teacher of high school mathematics who has not used in his teaching the portraits of the men who produced the science he is dealing with, can realize the added zest the use of these portraits brings.

The Open Court Publishing Company and Professor Smith are performing a genuine service to American teaching, in bringing within so easy reach of teachers of high school mathematics the portfolio of portraits of the following twelve eminent mathematicians: Thales, Pythagoras, Euclid, Archimedes, Leonardo of Pisa, Cardan, Vieta, Napier, Fermat, Descartes, Leibnitz, and Newton.

The portraits, which are photographic reproductions of the best extant originals, are issued in two forms, the prices being $5.00 and $3.00. The writer has seen only the cheaper form of the portraits, and that is very well done.

Each portrait is accompanied by a brief biographical note. The notes are well calculated both to give a fair idea of the man and his work, and to whet the appetite for more information about the man and his time. The portraits have been used with good results in connection with the work of the Mathematical Club of the University High School of the School of Education and teachers of high school classes will hardly be willing to get along without them after they have once used them.   G. W. Myers.

COLLEGE BOTANY.

Professor G. F. Atkinson.
Henry Holt & Co.

This is the Elementary Botany that was published in 1898, now rewritten and greatly elaborated. It is divided into five parts, as follows: I. Physiology; II. Morphology and the life history of representative plants; III. Plant members in relation to environment; IV. Vegetation in relation to environment; and, V. Representative families of Angiosperms. The order given is the one in which the author thinks the divisions should be considered, but it is suggested in the preface that any other order may be observed. The first 135 pages cover the general field of plant physiology, and include text discussions, suggestions for and descriptions of experiments. Together with the outline for the experiment is a statement of results that should follow and the significance of the facts thus demonstrated. This close association of discussion of results with the outline for an experiment has not been found by most teachers to be conducive of independence on the part of students.

In the second section *Spiroygra* is the simplest plant considered, the type forms that follow it being for the most part those usual in courses in plant morphology. It would seem that a college course in botany which takes account of morphology should present some of the simple algae which precede *Spiroygra* in simplicity. The text discussion in connection with type forms is most excellent and in presentation strikes a middle ground between elementary texts and the more technical college books.

Sections III. and IV. are on two phases of ecology, and constitute an adequate statement of this field for the general college student. The last section consists of work in classification and taxonomy. This section is not a manual, but a brief presentation of the chief features of the most important families of Angiosperms with suggestions for study of type forms. Such a study should certainly be included in a general course in botany. The appendix discusses "Collection and Preservation of Material," "Apparatus and Glassware," and "Reagents," and includes a brief list of reference books.

The book ought to find a place in a large number of colleges and in some of the best high schools.

RESEARCH METHODS IN ECOLOGY.

F. E. Clements.
Unviersity Publishing Co., Lincoln, Neb.

This is the most important book that has been published in America upon the subject of plant ecology.

The author has done a great deal of work in the field of which he writes and has produced a book that for some time to come will be all but essential to any one who is following a line of research work in plant ecology. Furthermore, the materials presented are such that workers in animal ecology, physiography and meteorology will find the book of immense value. If the suggestions made for painstaking, accurate, intensive and extensive experimentation were followed by all ecologists, we should have a sudden reduction in the amount of current ecological literature and a corresponding rise in its value.

The book consists of four sections, the first one being on "The Foundations of Ecology." In this are presented the author's views as to the relation of ecology to other phases of botany, zöology, and sociology. It is stated that "the whole task of ecology is to find out what the living plant and the living formation are doing and have done in response to definite complexes of factors, i. e., habitats. In this sense ecology is practically coextensive with botany, * * *" The physiologists and morphologists may claim that their subjects are not merely divisions of ecology, as might be inferred from the above, but that they have a separate and distinct function to perform in trying to determine "what the living plant and living formation are doing and have done in response to definte complexes of factors." While consideration of plants from the point of view of morphology, physiology, economic botany, etc., must necessarily have ecological bearings at times, ecology proper must presuppose knowledge of plants from these different points of view, and apply this knowledge in experimentation with plant parts, with the individual plant, and with the formation or plant society, and this is physiology applied in both laboratory and field. The author presents very forcibly the fact that mere superficial description of plant groups is not ecology in any dignified sense. In addition to including lines of study already indicated, ecology must consider evolution, taxonomy, forestry, pathology, soil physics, physiography and climatology.

The subject of ecology is divided into three heads: "habitat, plant, and formation (or vegetation)," the bulk of the book being given to these topics. In the section on habitat, in addition to a discussion of the nature and influence of factors of the habitat, there are presented extensive descriptions of the points to be determined in the habitat, instruments for determining these points and the proper methods of handling these instruments. The author has devised valuable ecological apparatus and his experience with this and other instruments as here described consti-

tutes a distinct contribution to the subject. One of the best things found in this section of the book is the constant demand for the sort of extensive investigation and constant accuracy that will eliminate the unfounded generalizations so common in ecological studies.

The sections on "The Plant," and "The Formation," are as much in the nature of discussions of the ecology of these things as on the research methods. They contain a thoroughly admirable statement of the ecology of the plant and the formation and most valuable suggestions as to the methods of investigating them.

A surprisingly large number of new terms have been created and used throughout the book, and some readers will probably accuse the author of being a faddist along this line. Many of these terms are of evident advantage, but we must question whether we are justified in trying to learn so large a collection of new technical terms, perfectly well based though they are on Greek and Latin roots. A *phellad* is "a rock field plant;" a *phretad*, "a tank plant;" a *pagophytium*, "a foothill plant," etc., etc. A glossary defines the most of the terms used. The book is without an index.

The points to be adversely criticised are decidedly unimportant when compared with the very great amount of valuable material in the book. It will do more than any other influence now before us to direct ecological research along profitable lines.

BOOKS RECEIVED.

"Our First Century," by George Cary Eggleston. Published by A. S. Barnes & Co., New York, 1905, 268 + xiii pages, $1.20, net.

"The Approved Selections for Supplementary Reading and Memorizing." First Year. Published by Hinds, Noble & Eldredge, New York, 59 pages, 25 cents.

"American Insects," by Vernon L. Kellogg, Leland Stanford, Jr. University. Published by Henry Holt & Co., New York, 674 pages.

PUBLISHERS' NOTICE.

Owing to the strike of printers in the house doing the printing for ''SCHOOL SCIENCE AND MATHEMATICS,'' the publishers are laboring under many difficulties in order to get the Journal into the hands of its readers on the first of the month. We are asking our readers to overlook any mistakes which may be noticed. We hope to bring out the November number in good form and on time.

SCIENCE AND MATHEMATICAL SOCIETIES.

Under this heading is published each month the name and officers of such societies as furnish this information.

Central Association of Science and Mathematics Teachers.

President, Otis W. Caldwell, State Normal School, Charleston, Ill.
Secretary, Chas. M. Turton, 440 Kenwood Terrace, Chicago, Ill.
Treasurer, E. Marsh. Williams, High School, La Grange, Ill.
Annual meeting Friday and Saturday immediately following Thanksgiving.

Chicago Center, C. A. S. and M. T.

President, W. C. Hawthorne, Central Y. M. C. A., Chicago.
Vice-President, P. B. Woodworth, Lewis Institute, Chicago.
Secretary, C. E. Osborne, High School, Oak Park, Ill.

North-Eastern Ohio Center, C. A. S. and M. T.

President, Franklin T. Jones, University School, Cleveland.
Vice-President, Miss Winona A. Hughes, High School, Mansfield, Ohio.
Secretary-Treasurer, Clarence W. Sutton, Central High School, Cleveland.

Association of Ohio Teachers of Mathematics and Science.

President, William McPherson, Ohio State University, Columbus.
Vice-President, Franklin T. Jones, University School, Cleveland.
Secretary, Thomas E. McKinney, Marietta College, Marietta.

Science Section of the Michigan School Masters' Club.

Chairman, H. M. Randall, Ann Arbor.
Vice-Chairman, F. C. Irwin, Central High School, Detroit.
Secretary, DeForrest Ross, Ypsilanti.